Profitable Opportunities around Macroeconomic Announcements in the U.S. Treasury Market

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Abstract

This thesis studies the impact of macroeconomic announcements on the U.S. Treasury market and investigates profitable opportunities around macroeconomic announcements using data from the eSpeed electronic trading platform. We investigate how macroeconomic announcements affect the return predictability of trade imbalance for the 2-year, 5-year, 10-year U.S. Treasury notes and 30-year U.S. Treasury bonds. The goal of this thesis is to develop a methodology to identify informed trades and estimate the trade imbalance based on informed trades. We use the daily order book slope as a proxy for dispersion of beliefs among investors. Regression results in this thesis indicate that, on announcement days with a high dispersion of beliefs, daily trade imbalance estimated by informed trades significantly predicts returns on the following day. In addition, we develop a trade-imbalance based trading strategy conditional on dispersion of beliefs, informed trades, and announcement days. The trading strategy yields significantly positive net returns for the 2-year T-notes.

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1. Introduction

The objective of this thesis is to study how macroeconomic information arrival, informed trading and dispersion of beliefs among investors affect the informational role of trade imbalance in predicting the U.S. Treasury returns. Many studies have been developed to explore the relation between financial returns and trade imbalance. Hasbrouck (1996) shows that total trade imbalance explains 7.5% of the variance in thirty minute returns in the New York Stock Exchange (NYSE). Chordia et al. (2008) find significant results that trade imbalance predicts five-minute returns, but the predictability is diminished during the liquid periods. Moshirian et al (2009) find that both trade imbalance and order book slope imbalance predict thirty-minute returns in Australian Securities Exchange and the predictability is strengthened when there are public information arrivals.

While many studies focus on the return predictability of trade imbalance at intraday level, we investigate return predictability of trade imbalance at a daily level. Within a short-time interval, when liquidity and informed traders buy (sell), prices will move up (down). Therefore, trades by liquidity traders can also contribute to a positive return predictability of trade imbalance within a short-time interval. We examine return predictability of trade imbalance at daily level to reduce the liquidity effects on prices.

The previous studies that examine the return predictability of trade imbalance estimate the trade imbalance based on aggregate trades without differentiating informed trades from liquidity trades. This thesis contributes to the literature on trade imbalance estimation by differentiating informed trades from liquidity trades and estimating trade imbalance based on informed trades only. If we simply estimate trade imbalance based on aggregate trades, trade imbalance may not be a good indicator of the position that informed traders take. Trade imbalance should be more informative when we consider informed trades only. This thesis uses aggressive trades as a proxy for informed trades. Motivated by Abad and Rubia (2004) and Harris and Hasbrouck (1996), which show that aggressive orders are likely to be submitted by informed traders, this thesis develops a methodology to differentiate informed trades from liquidity trades based on order aggressiveness. We believe that informed traders with short-lived information are more likely to act impatiently and place aggressive orders.

However, whether informed traders are more likely to use aggressive orders is a controversial issue in the existing literature. On one hand, there are studies (Easley and O'Hara, 1992; Beber and Caglio, 2005; Lo and Sapp, 2007) documenting that informed traders tend to trade less aggressively to hide their private information. On the other hand, some studies (Abad & Rubia, 2004; Lo & Coggins, 2006; Ma et al., 2007) argue that with short-lived information, informed traders would like to place aggressive orders. This thesis examines the relationship between aggressive orders and informed trades by looking into the return predictability of trade imbalance based on aggressive trades. First of all, we estimate trade imbalance by using aggressive trades. If informed traders are more likely to place aggressive orders, trade imbalance estimated by aggressive orders should be more informative on future returns. We believe that return predictability of trade imbalance is a better measure for the relationship between aggressive orders and informed trading, since this measure directly investigates information content of the aggressive trades.

In addition, this thesis examines how the dispersion of beliefs affects the return predictability of trade imbalance on macroeconomic announcement days. The U.S. Treasury market is mainly driven by the release of macroeconomic indicators and Treasury prices largely react to the arrival of public information aboutthe economy. It is of great interest to investigate how macroeconomic announcements affect the return predictability of trade imbalance, since public news can raise the degree of dispersion of beliefs among investors and trigger informed trading. Moshirian et al. (2009) suggest that if an announcement is not easy to interpret by all the investors, skilled traders can extract private information from the announcement. We believe that skilled traders may take advantage of the announcements that are hard to interpret and speculate in the Treasury market. In turn, the trade imbalance on the announcement days with a high dispersion of beliefs among investors should be more informative on future returns.

Moreover, this thesis can be viewed as a study of market efficiency when public information is hard to interpret. In semi-strong efficient markets, prices should reflect public information instantly and investors should not be able to predict returns using public information (Fama, 1970). However, during macroeconomic announcement days with high dispersion of beliefs among investors, it may take longer for prices to adjust to public information. On these days, skilled traders may be able to predict futures prices and generate positive dollar returns. We examine the efficiency of the treasury markets by investigating return predictability.

To measure the dispersion of beliefs, we use the order book slope, which was developed by Naes and Skjeltorp (2006). The order book slope is calculated by the average elasticity of the supply and demand schedules in the order book, which captures dispersion of beliefs among investors. Although there are many studies (Diether et al., 2002; Kallberg & Pasquariello, 2008; Green, 2004; Pasquariello & Vega, 2007) measuring dispersion of beliefs by the standard deviation across professional forecasts for the macroeconomic indicator in the Treasury market, we believe that the order book slope is a better measure. While the standard deviation across professional forecasts captures the divergence of opinions among investors on the value of a macroeconomic indicator, the order book slope measures the dispersion of beliefs among investors directly on the asset value itself. Therefore, we believe that the order book slope reflects investors' expectations better. However, the GovPX Treasury data that current studies use contains quote and size information only for the first tier[1], so they cannot calculate the order book slope as a proxy for dispersion of beliefs. This thesis conducts the study based on the newly available U.S. Treasury data from the electronic platform, eSpeed, which contains all the trading information for six tiers and enables us to calculate the order book slope in the Treasury market.

[1] The first tier shows the trading information for the best bids and asks. The best bid (ask) denotes the highest (lowest) bid (ask) price.

The empirical results of this thesis show that, on the macroeconomic announcement days with high dispersion of beliefs, daily trade imbalance estimated by aggressive trades strongly predicts returns on the following day for the 2-year, 5-year and 10-year Treasury notes. Chordia et al. (2002), and Chordia and Subrahmanyam (2004) find a positive and significant relation between lagged daily imbalance and returns in stock markets, but the relation becomes negative after controlling for current imbalance, since the effect of current imbalance overweighs the impact of current trades that are auto-correlated with past trades. Chordia and Subrahmanyam (2004) also propose that a large trade imbalance before an informational event could denote informed trading, but the informational impact of trade imbalance on returns is left for future research.

This thesis adds to the literature by investigating the informational effect of trade imbalance on treasury returns. This thesis provides empirical evidence that even after controlling for the current trade imbalance, on the macroeconomic announcement days with high dispersion of beliefs, the relationship between the daily trade imbalance estimated by aggressive (informed) trades and returns on the following day is still significant and positive. This result provides supporting evidence that the return predictability of the trade imbalance is attributed to the information content of the trade imbalance by informed trades, rather than the auto-correlation between the current and past trades. Moreover, this result provides supporting evidence that skilled (informed) traders trade aggressively to take advantage of their information and that skilled traders are likely to speculate on macroeconomic announcement days with high dispersion of beliefs.

Furthermore, based on the regression results, we develop a trade-imbalance based trading strategy conditional on dispersion of beliefs and announcement days. The trading strategy yields positive returns for 2-year, 5-year and 10-year Treasury notes but the positive returns are only significant for the 2-year notes when the daily order book slope is 25% and 30% lower than the average slope of the previous 365 days.[2]

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[2] Low slope implies high dispersion of beliefs. Please see methodology section for details.

The rest of this thesis is organized as follows. In Section 2, a brief literature review is provided. Section 3 presents a description of eSpeed U.S. Treasury data and the macroeconomic announcement data. Section 4 describes the methodology and model development. In Section 5, descriptive statistics and empirical results are provided. Section 6 develops a trading strategy based on the regression results. Section 7 presents a summary for this thesis.

2. Literature Review

This thesis investigates the return predictability of trade imbalance and how macroeconomic announcements, informed trading and dispersion of beliefs among investors affect the return predictability. Therefore, the following literature review focuses on previous studies in the fields of return predictability of trade imbalance, impact of macroeconomic announcements, informed trading and order aggressiveness as well as dispersion of beliefs.

2.1 Return Predictability of Trade Imbalance

The main contribution of this thesis is to study the return predictability of trade imbalance in the U.S. Treasury market and how the predictability changes around macroeconomic releases and periods with high dispersion of beliefs. Trade imbalance is calculated as the number of buyer initiated trades minus seller initiated trades. To some degree, trade imbalance reflects investors' views of the market and their expectation for future prices. A positive (negative) trade imbalance signals the investors' expectations in price increase (decrease) in the future. Trade imbalance can signal private information and in turn reduce liquidity temporarily, and affect the market price (Kyle, 1985).

Existing literature documents that trade imbalance contains significant information and is closely related to future prices in various financial markets. Hasbrouck (1996) shows that total trade imbalance explains 7.5% of the variance in thirty- minute returns in the New York Stock Exchange (NYSE). Chordia et al. (2002) study trading activity in the New York Stock Exchange. They provide supporting evidence that one-sided trade imbalance, excess buying or selling, reduces market liquidity, and market returns are strongly affected by current and lagged trade imbalance. They show that daily lagged trade imbalance significantly and positively predicts future returns, but the relation becomes negative after controlling for contemporaneous trade imbalance. Breedon and Vitale (2004) suggest that trade imbalance conveys information, which directly impacts the exchange rates in the foreign exchange market. Similar to Chordia et al. (2002), Chordia and Subrahmanyam (2004) find a positive relation between lagged daily trade imbalance and returns in the stock market, but the positive relationship become negative after controlling for the current imbalance. In addition, they develop a trading strategy based on trade imbalance, which yields statistically significant returns. Lo and Coggins (2006) show that the degree of return reversal is positively related to the level of trade imbalance in the Australian equity market. Brandt et al. (2007) suggest that the current impact of the trade imbalance on the future and cash market is significant and permanent, but the impact of the lagged trade imbalance is not significant. Moreover, they find that futures and spot market trade imbalances are good predictors of daily returns in each market and that the type of trader[3] influences the effect of trade imbalance. Chordia et al. (2008) investigate all NYSE firms in a sample period and run a regression of five-minute returns on past five-minute trade imbalance. They find significant results that trade imbalance can predict five-minute returns, but the predictability is diminished during the liquid periods. Moshirian et al. (2009) regress thirty- minute returns on one lagged trade imbalance and order book slope imbalance in the Australian Securities Exchange without controlling for the current trade imbalance. They show that both trade imbalance and order book slope imbalance predict future returns and that the predictability is strengthened when there are public information arrivals.

Unlike the equity market, the U.S. Treasury market is mainly driven by public news. However, public information can also trigger private opinions, since market participants have different abilities to interpret public information (Kim & Verrecchia, 1994; Green, 2004). Thus, to some extent, trade imbalance in the Treasury market can reveal private information and predict future returns. Brandt and Kavajecz (2004) find a negative correlation between current net trade imbalance and yields (excess demand pushes prices up and therefore lower yields) in the Treasury market. The effect of trade imbalance increases when liquidity is lower. Green (2004) finds that trade imbalance contains little information before the release of economic news and more information after the release. The increased information content of trading following the announcements demonstrates

[3] Brandt et al (2007) define traders in 4 categories: 1. Individual CBOT members. 2. CBOT clearing member firms trading for their house accounts. 3. CBOT members filling orders for other CBOT members. 4. Public customers. The results suggest the order flow is more informative when the order falls into category 2, 3, and 4.

that the releases of the macroeconomic indicators raise the level of information asymmetry in the Treasury market. Pasquariello and Vega (2007) provide evidence that adverse selection costs of unanticipated trade imbalance in the U.S. Treasury market are higher when the dispersion of beliefs is higher. Ozocak and Han (2009) find that trade imbalance in London trading hours is significantly and positively related to the bond price changes in the U.S. trading hours on macroeconomic announcement days.

While the previous studies examine the information content of aggregate trade imbalance, this thesis develops a proxy to differentiate informed trades from liquidity trades and estimates daily trade imbalance based on aggressive (informed) trades only. The trades by liquidity traders may create a noise in the return predictability of the trade imbalance, since the liquidity traders possess no private information. The trade imbalance estimated by informed trades is a better indicator of the position that informed traders take, which should be more informative for future price. Moreover, we add to the current literature by investigating the return predictability of daily trade imbalance on the announcement days with high dispersion of beliefs in the U.S. Treasury market. The dispersion of beliefs is measured by the daily order book slope. Pasquariello and Vega (2007) find that unanticipated trade imbalance is negatively and significantly correlated with bond yield changes when dispersion of beliefs among informed traders is higher and when public announcement is noisy. Therefore, we expect that trade imbalance is more valuable to convey private information on the announcement days with high dispersion of beliefs in the U.S. Treasury market. Current literature (Chordia et al., 2002; Chordia & Subrahmanyam, 2004) show that daily lagged trade imbalance and current returns are positively related when current trade imbalance is not included in the regressions, but the relation between past trade imbalance and current returns is significantly negative after controlling for current trade imbalance because of inventory effects. Different from the previous literature, we investigate the relationship between trade imbalance (estimated by informed trades) and returns on announcement days with high dispersion of beliefs.

2.2 Impact of Macroeconomic Announcements

The U.S. Treasury market is mainly driven by the release of macroeconomic indicators. Macroeconomic indicators can show the overall economic development and indicate a growth or a decline in economy, may lead to a great influence on the Treasury market. In contrast to stock prices, the U.S. Treasury prices largely react to the arrival of public information on the economy, since bond prices depend only on expected discount rates while stock prices are also determined by future expected dividends.[4] The cash flow of Treasury securities is known and their prices are mainly affected by macroeconomic news releases (He et al., 2009). Thus, it is of great importance to study the information effect of macroeconomic announcements on the Treasury market. We focus on the scheduled U.S. macroeconomic announcements, which are released at precisely identifiable times. The high frequency Treasury data obtained from the electronic platform eSpeed enables us to examine market liquidity, the dispersion of beliefs, as well as the return predictability of trade imbalance in response to macroeconomic announcements. This thesis investigates how public news arrivals affect the informativeness of trade imbalance on Treasury returns, especially during the days with high dispersion of beliefs among investors.

Nikkinen and Sahlstrom (2001) find that market uncertainty decreases after U.S. macroeconomic announcements on the stock market. Thus, according to Nikkinen and Sahlstrom (2001), we should expect that the release of public news reduces information asymmetry and dilutes the information advantages of the informed traders. However, Moshirian et al (2009) argue that if informed traders have superior skills to extract private information, private information may be created by public information arrivals which are hard to interpret. In turn, the public information arrivals offer information advantages to the informed traders. Moshirian et al., (2009) also provide empirical evidence that public news releases increase the return predictability of trade imbalance at the 5-minute level in the Australian Securities market.

Differently from Moshirian et al., (2009), this thesis examines the daily return predictability of trade imbalance on announcement days when the announcements are

[4] Fleming and Remolona (1999) indicate that bond prices react more strongly to macro announcements than do equity market. They examined the 25 largest price changes in the GovPX data and related them all to macroeconomic announcements and significant announcement effects were found. However, Macro announcements can have little or no effect on stock prices if their effects on expected dividends and discount rate offset each other.

hard to interpret. If macroeconomic announcements are hard to interpret, only skilled traders can extract private information from the announcements. Thus, on the announcement days with high a dispersion of beliefs among investors, trade imbalance estimated by the informed trades may be more informative for future returns. If the announcements are not easy to understand, it may take a longer time for the price to adjust to the public information. We expect that, on the announcement days with a high dispersion of beliefs, the trade imbalance estimated by the informed trades can significantly and positively predict future returns.

In addition, a large body of literature has examined the effect of macroeconomic announcements on the Treasury market liquidity. Fleming (1997) was the first to conduct a comprehensive intraday study of the round-the- clock market for the U.S. Treasury. The study finds that trading volume is lower during Tokyo trading hours and remains steady throughout London hours, but significantly increases between 8:30 am and 9 am in New York trading hours, which can be explained by the macroeconomic announcements releases at 8:30 am. Balduzzi et al. (2001) show that price volatility and trading volume increase significantly after macroeconomic announcements. Green (2004) examines the impact of trading on Treasury bond prices around the release of macroeconomic news. A large increase in the informational role of trading with a larger initial price impact is observed following macroeconomic announcements. Mizrach and Neely (2007) find that the employment, PPI, CPI and durable goods orders releases produce the greatest impact on the U.S. Treasury bonds. Chatrath et al. (2009) provide supporting evidence that the largest adjustments in the inventory component are made following macroeconomic announcements, towards the start and end of New York trading hours, as well as when transaction sizes are large. He et al. (2009) find that information asymmetry is higher in the opening period of the New York market (8:30am–9:00am) during the macroeconomic announcement days. Using eSpeed data, Dungey et al. (2008) examine the price volatility and trading volume in each one-minute interval around the 8:30 am announcement time in the 10-year T-notes market. They find that price volatility and trading volume do not vary around 8:30am on non-announcement days while price volatility and trading volume increase immediately following the macroeconomic announcements.

We extend previous literature by providing statistics for trading volume, trading frequency, trade size, quote-size, daily absolute number of trades and bid-ask spread in the U.S. Treasury market for non-announcement and announcement days conditional on a high dispersion of beliefs among investors. The Treasury data from GovPX, which is used in most previous studies, contains only the trading information for the best bid and ask, from which we cannot obtain information about the dispersion of beliefs among investors. This thesis takes advantage of the newly available high-frequency Treasury data from the electronic trading platform eSpeed that contains trading information of six tiers, which enables us to calculate the daily order book slope and to measure the daily dispersion of beliefs among investors.

2.3 Informed Trading and Order Aggressiveness

The trades by liquidity traders may create a noise in the return predictability of trade imbalance. This thesis contributes to current literature on trade imbalance estimation by differentiating informed trades from liquidity trades based on aggressive (informed) orders and estimating the trade imbalance based on informed trades only. The trade imbalance calculated by informed trades can better represent the position that the informed traders take, which should be more informative on future returns.

The U.S. Treasury data we use is obtained from the eSpeed electronic platform, which is an order-driven market. In an order-driven market, there is no centralized decision maker, so that prices arise from the interaction of a large number of traders (Rosu, 2010). It is of great interest to study the relationship between prices and the position that informed traders take. Being motivated by Abad and Rubia (2004) and Harris and Hasbrouck (1996), who show that aggressive orders are submitted mainly by informed traders, we develop a methodology to differentiate informed trades from liquidity trades based on order aggressiveness. We believe that informed traders with short-lived information are more likely to act impulsively and place aggressive orders.

However, whether informed traders are more likely to trade aggressively is a controversial issue in the existing literature. Foster and Viswanathan (1990) suggest that low volume and high volatility are related to informed trading. Easley and O'Hara (1992) suggest that since large orders can reveal more information, informed investors may split their orders into smaller amounts in order to trade without information disclosure. Beber and Caglio (2005) find that the orders are less aggressive when there is a higher probability of information-based trading, suggesting that informed traders are more likely to use less aggressive orders in the NYSE. Lo and Sapp (2007) find that dealers are more likely to break large orders into a string of smaller orders to more gradually reveal their information in the foreign exchange market.

On the other hand, Glosten (1994) and Seppi (1997) suggest that with short-lived private information, informed traders are impatient and prefer a more aggressive order, market orders, instead of limit orders. Griffiths et al. (2000) demonstrate that aggressive orders are associated with a greater price impact. Abad and Rubia (2004) find that the order aggressiveness is closely related to an informed trading process in which prices are updated. Most aggressive orders are likely submitted by informed traders. The more aggressive the order is, the more information is conveyed. They provide statistical evidence that the arrivals of a particular type of aggressive order impose the highest revision in mid-quotes. Lo and Coggins (2006) suggest that traders can be divided into informed and uninformed traders in the market microstructure literature. Informed traders would want to trade larger quantities when they have valuable information. Ma et al. (2007) provide evidence that trades with large volumes are associated with a higher probability of informed trading in an order-driven market.

This thesis conducts regression analyses to examine the relationship between aggressive orders and informed trades. We consider aggressive orders[5] as proxy for informed trades and estimate trade imbalance by using aggressive trades. If informed traders are more likely to place aggressive orders when they possess private information, the return predictability of trade imbalance estimated by aggressive orders should increase. Return predictability of trade imbalance is a better measure for the relationship between aggressive orders and informed trading, since this measure directly investigates the

[5] We define the informed trades in section 4.2 in more details.

information content of the aggressive trades. If an aggressive trade is a good proxy for an informed trade, trade imbalance estimated by aggressive trades should be more informative on future returns. Hence, the results from this thesis will help us better understand whether informed traders are more likely to trade aggressively.

2.4 Dispersion of Beliefs

This thesis investigates how the dispersion of beliefs among investors affects the return predictability of trade imbalance in the U.S. Treasury market. Dispersion of beliefs can arise in the Treasury market because investors can have different interpretations of the public news. Green (2004) suggests that price movement in the Treasury market is induced by the dispersion in traders' interpretation of public news. He finds that the informational role of trading significantly increases following economic announcements, indicating that the release of public information increases the level of information asymmetry in the government bond market. Their results suggest that information asymmetry in the government bond market arises not from the lack of relevant public information, but from differences in the ability of market participants to interpret the information. Based on the MRR[6] model, Green (2004) shows that the sensitivity of prices to trade imbalance depends on the prevailing level of information asymmetry. He et al. (2009) agree that information asymmetry in the Treasury market is mainly derived from the heterogeneous interpretation of public information. Different abilities to analyze the public news create information asymmetry among traders. Based on the MRR model, they find that the trade imbalance contains more information when there is higher asymmetric information.

Standard deviation of macroeconomic forecasts can be used to measure the information asymmetry during macroeconomic announcements. The forecasts represent the professionals' views on the upcoming announcements. Thus, the standard deviation of forecasts indicates how the opinions differ among the professionals. A high standard deviation of macroeconomic forecasts represents a high level of information asymmetry,

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[6] See Green (2004): MRR model (Madhavan, Richardson, and Roomans) is a generalized version of earlier microstructure models, which attributes transaction price changes to unanticipated public information and microstructure effects, and decomposes effective spreads into absolute components rather than relative spread shares.

while a low standard deviation indicates a low level of information asymmetry. Diether et al. (2002), Kallberg and Pasquariello (2008), Green (2004) and Pasquariello and Vega (2007) use the standard deviation among professional forecasts as a measure of dispersion of beliefs across sophisticated investors in the stock market. Pasquariello and Vega (2007) find that a greater dispersion of beliefs among speculators reduces market liquidity during announcement days only when the public information is noisy. They provide evidence that unanticipated trade imbalance is more highly correlated with bond yield changes, indicating that the informativeness of trade imbalance is positively related to the dispersion of investor beliefs.

Alternatively, Naes and Skjeltorp (2006) use order book slope to estimate the dispersion of beliefs among investors in the equity market. They measure the order book slope by the average elasticity of the supply and demand schedules in the order book. The steep order book slope indicates that there is a high degree of agreement among investors about the fair value of an asset while a gentle order book slope indicates that there is greater disagreement among investors about the fair value of an asset. The intuition behind this is that the more gentle (steeper) the slope is, the more dispersed (concentrated) the volumes in the order book are, which reflects more (less) dispersion of beliefs among investors. They find that the number of trades and price volatility are negatively related to the order book slope, indicating that when there is more dispersion of beliefs, there are more trades and price volatility. Jiang and Lo (2008) estimate the dispersion of beliefs using order book slope in the U.S. Treasury market. They argue that the standard deviation across professional forecasts in previous literature may not be a good measure of dispersion of beliefs among investors since the forecast is stale between the forecast release date and announcement release date. In addition, the forecast is made on the value of the macroeconomic indicators but not directly on the value of an asset. However, the order book slope measures the dispersion of beliefs among investors directly on an asset value itself. Thus, we argue that the order book slope is a better measure of dispersion of beliefs among investors on the fair value of an asset. In addition, the limit order book is placed by real money and should more accurately reflect private beliefs. Jiang and Lo (2008) find that the highest group of PIT (probability of informed trading) is associated with the gentlest order book slope for the 2-, 5- and 10-year U.S. Treasury notes. Duong and Kalev (2008) investigate the information content of the limit order book in the Australian Stock Exchange. Based on a GARCH model, they find that the order book slope is negatively related to future price volatility, which indicates that when there is more dispersion of beliefs, there is higher price volatility. Moshirian et al. (2009) provide supporting evidence that the relation between price volatility and the order book slope enhances as the intensity of public information arrivals increases. They also show that the slope of the demand curve over the supply curve of the order book could predict half-hour stock returns in the Australian Securities Exchange, which is consistent with the notion in Glosten (1994) and Beber and Caglio (2005) that the order book contains information on prices.

To our knowledge, this is the first study that examines the reaction of Treasuries to macroeconomic indicators conditional on high dispersion of beliefs when dispersion is measured by the order book slope. Since the slope measure should be a better proxy for the dispersion of beliefs following macroeconomic announcements, results in this study should improve our understanding of how the U.S. Treasuries react to public information.

3. Data Description

3.1 Macroeconomic Announcement Data

The data of Macroeconomic announcements, macroeconomic consensus data, and consensus range are obtained from Econoday online. The consensus data is the median of professional forecasts for an upcoming macroeconomic release. Econoday Online is a subscription-based online resource that reports U.S. economic and U.S. Treasury events. Econoday begins each day reading Market Focus, which highlights the events of critical importance of that day. Updates of announcements are posted in Econoday, including consensus and actual release data accompanied by unbiased, jargon-free, market-focused analysis written by their team of economists.[7] The sample for the sixteen macroeconomic announcements covers the periods from June 2005 to May 2008. We provide a brief explanation for each of the sixteen macroeconomic indicators in Appendix 1. The release time, frequency and source about the announcements are presented in Appendix 2.

3.2 U.S. Treasury Data

The source of the U.S. Treasury data is eSpeed founded by Cantor Fitzgerald and Co, which is an electronic trading system that automatically matches buy and sell orders at specified prices. Most of the previous research on the U.S. Treasury market used treasury data from voice-assisted brokers, as reported by GovPX. As Fleming and Mizrach (2009) mention, GovPX receives market information from IDBs (Interdealer brokerages) and releases the information in real time through the internet and data vendors. However, in more recent years, the voice-assisted trading which GovPX represents has been largely replaced by electronic trading. Electronic trading has begun to dominate in many financial markets, such as equities, foreign exchange, and most recently, the U.S. Treasuries. Cantor Fitzgerald and BrokerTec account for most of the market share in recent years. [8] Mizrach and Neely (2006) show that Cantor Fitzgerald is the second largest IDB in the overall secondary Treasury market, following BrokerTec (ICAP). Mizrach and Neely (2006) estimate that BrokerTec accounts for 61% of trading activity in on-the-run securities and eSpeed 39%. Thus, we believe that eSpeed data is a good

[7] Source from Econoday

[8] See Mizrach and Neely(2006) for details

representative of the U.S. Treasury market. Moreover, eSpeed offers a real-time graphic-enhanced quotation system with an accurate historical database. The timing of the eSpeed dataset is accurate to a millisecond, while the timing of Gov-PX dataset is accurate to seconds. We believe that the eSpeed data of Cantor is more representative of the market since not only its timing is more accurate, but it also includes six tiers of the quotes and sizes.

The U.S. Treasury market is the largest and most active debt market in the world. A great number of Treasury securities are traded every business day. The U.S. Treasury market consists of primary and secondary markets, involving numerous participants – the Department of the Treasury, the Federal Reserve System, government dealers and brokers, and other holders of Treasury securities.[9] The trading in the secondary market for U.S. Treasury securities takes place 22-23 hours a day, five days a week. According to Fleming (1997), the global trading times for the U.S. Treasury market is as follows: **(1)** the trading begins in Tokyo at local time 8:30 am (7:30 pm ET), and continues to local time 4 pm in Tokyo (3 am ET), **(2)** London trading begins at local time 8 am (3 am ET), and continues to local time 12:30 pm in London (7:30 am ET), **(3)** New York trading begins at 7:30am ET and continues until 5:30 pm ET. [10]

This thesis analyzes trading in the U.S. Treasury market on the basis of the newly available and high-frequency intraday data from eSpeed, for the periods between June 1, 2005 and May 30, 2008. eSpeed is a fully automated electronic trading platform where buyers are matched to sellers without human intervention. The data record is created whenever the trading system publishes a market update, including six levels of limit order book, market state and volume. The trading process on the eSpeed platform follows an auction-based model. The trading system accepts bids and asks at multiple price levels for the same security. Bids and asks are passive orders. A trade begins when a seller (buyer) aggresses on an existing bid (ask). Once a trade starts, participants can take part in a work-up stage, buying or selling more volume at the trade price.

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[9] See the Federal Reserve Bulletin December 1999
[10] See Fleming (1997)

3.3 Macroeconomic Surprises

We calculate macroeconomic surprises by taking the differences between actual announcement releases and their consensus value. Further, we standardize the resulting surprises by dividing each of them by their sample standard deviation for each announcement. The reason for standardization is to compare the surprise across different announcements. The macroeconomic surprise associated with the macroeconomic indicator j at time t is shown as

$$S_{jt} = \frac{A_{jt} - \mu_{jt}}{\hat{\sigma}_j} \tag{1}$$

Where A_{jt} is the actual macroeconomic statistic of announcement , μ_{jt} denotes the corresponding consensus value, and $\hat{\sigma}_j$ is the sample standard deviation of $A_{jt} - \mu_{jt}$ for announcement j.

In section 5.1, we provide descriptive statistics for the 8:30 am announcement days with high macroeconomic surprises. If there is more than one 8:30am announcement on the same day, we calculate the daily macroeconomic surprise by taking the average of different 8:30am announcement surprises as follows:

$$S_t = \frac{\sum_{n=1}^{j} S_{jt}}{j} \tag{2}$$

3.4 Forecast Range

We calculate the standardized range for the macroeconomic surveys as follows:

$$Rg_{jdt} = \frac{H_{jdt} - L_{jdt}}{\widehat{std}_j} \tag{3}$$

Where H_{jdt} is the highest professional forecast value for announcement j on day d and time t, L_{jdt} is the lowest professional forecast value of announcement j on day d and time t, $\widehat{std}_j$ is the sample standard deviation of $H_{jdt} - L_{jdt}$ for announcement j.

In section 5.1.8, Table 23, we provide order book statistics for the announcement periods with high and low forecast ranges. If there is more than one macroeconomic announcement released at the same time *t* and on the same day *d*, we calculate the forecast range on day *d* and time t by taking the average of those different forecast ranges for that day *d* and time *t*:

$$Rg_{dt} = \frac{\sum_{n=1}^{j} Rg_{jdt}}{j} \tag{4}$$

4. Methodology and Model Development

4.1 The Order Book Slope

We use the daily order book slope as a proxy for the dispersion of beliefs among investors. The current literature, Diether et al. (2002), Kallberg and Pasquariello (2008), Green (2004), and Pasquariello and Vega (2007), use the standard deviation across professional forecasts as a measure of dispersion of beliefs across sophisticated investors in the stock market. However, the standard deviation as a proxy for dispersion of beliefs may be misleading in the Treasury market since the forecast is stale between the forecast release date and announcement date, and the forecast is not based on the fair value of the asset itself.

Motivated by Naes and Skjeltorp (2006), we use the daily order book slope to measure the dispersion of beliefs among investors. The order book slope should be more directly related to the dispersion of opinions than to analysts' forecasts. Essentially, the order book slope measures the elasticity describing how the quantity supplied in the order book changes as a function of the price.[11]

We estimate the daily order book slope based on the eight hourly spaced snapshots of the order book: at 8:30am, 9:30am, 10:30am, 11:30am, 12:30pm, 13:30pm, 14:30pm, and 15:30pm. First, we calculate the aggregate volume supplied (demanded) for each tier at the end of each hourly interval. For example, for the first tier, the aggregate volume is equal to the volume in the first tier; for the second tier, the aggregate volume is equal to the sum of volumes in the first tier and the second tier; similarly, for the fifth tier, aggregate volume is equal to the sum of all the volumes in all five tiers. Second, we take the logarithm of the aggregate volume. Third, we obtain an average slope for the bid and ask sides for respective snapshots based on the aggregate volume and price at each tier. Fourth, we take the average of the bid and ask slope to get one slope measure for each snapshot. Finally, we take the average of the eight snapshots to obtain a daily average slope.

[11] See Naes and Skjeltorp(2006)

The order book slope at the end of each hourly interval is given by:

$$SLOPE_t^s = \frac{SE_t^s + DE_t^s}{2} \quad (s = 1,2 \dots 8), \tag{5}$$

where SE_t^s and DE_t^s is the order book slope of the supply side and the demand side for each snapshot. s indicates the snapshot. The order book slope of the ask side is given by:

$$SE_t^s = \frac{1}{N_a}\left\{\frac{v_1^A}{\frac{p_1^A}{p_0^A} - 1} + \sum_{\tau=1}^{N_a-1} \frac{\frac{v_{\tau+1}^A}{v_\tau^A} - 1}{\frac{p_{\tau+1}^A}{p_\tau^A} - 1}\right\} \quad (s = 1,2 \dots 8). \tag{6}$$

Similarly, the order book slope of the bid side can be calculated as:

$$DE_t^s = \frac{1}{N_a}\left\{\frac{v_1^B}{\left|\frac{p_1^B}{p_0^B} - 1\right|} + \sum_{\tau=1}^{N_b-1} \frac{\frac{v_{\tau+1}^B}{v_\tau^B} - 1}{\left|\frac{p_{\tau+1}^B}{p_\tau^B} - 1\right|}\right\} (s = 1,2 \dots 8), \tag{7}$$

where N_a and N_b is the total number of bid and ask prices at tick levels containing orders, which are equal to five in this thesis. Although our data contains the order book for six tiers, we find that there is only a small number of observations in the sixth tier. Thus, we only use the first five tiers to calculate the order book slope. τ is the tick level, where $\tau = 0$ denotes the bid and ask mid-point and $\tau = 1$ denotes the bid and ask quotes in the first tier with positive volumes. v_τ^A and v_τ^B represent the logarithm of the aggregate volume at tick level τ for the ask side and bid side respectively. p_τ^A and p_τ^B represent the ask and bid quote at tick level τ, respectively. To avoid zero in the denominator, we select the observations where the bid price is not equal to the ask price in the first tier, and where the bid and ask volume at the first level is larger than 1.

Finally, the daily slope of the order book on day t is calculated as:

$$SLOPE_t = \frac{1}{8}\sum_{s=1}^{8}\frac{SE_t^s + DE_t^s}{2} \quad (s = 1,2 \ldots 8) \tag{8}$$

A gentler slope indicates a wider range of quotes for a given volume and more diverse opinions over the value of the Treasury notes and bonds. An example to illustrate the calculation of order book slope is given in the following table.

Snapshot 1: June 03, 2005 Snapshot at 8:30am

	Ask Price	Volume	mid-quote
tier 1	100.023	40	99.996
tier 2	100.031	1	
tier 3	100.039	20	
tier 4	100.109	23	
tier 5	100.219	15	

Snapshot 2: June 16, 2005 Snapshot at 8:30am

	Ask Price	Volume	mid-quote
tier 1	99.586	15	99.582
tier 2	99.594	7	
tier 3	99.602	75	
tier 4	99.609	2	
tier 5	99.617	2	

The table shows the ask price and volume for five tiers. The first snapshot is from June 03, 2005, which was a macroeconomic announcement day with a high dispersion of beliefs. The second snapshot is from June 16, 2005, which was a macroeconomic announcement day with low dispersion of beliefs. The calculation of the order book slope for the two snapshots is as follows.

Order book slope for snapshot 1:

$$SE = \frac{1}{5}\left\{\frac{\log(40)}{\frac{100.023}{99.996}-1} + \frac{\frac{\log(1+40)}{\log(40)}-1}{\frac{100.031}{100.023}-1} + \cdots + \frac{\frac{\log(15+23+20+1+40)}{\log(23+20+1+40)}-1}{\frac{100.219}{100.109}-1}\right\}$$

$$= 1492$$

Order book slope for snapshot 2:

$$SE = \frac{1}{5}\left\{\frac{\log(15)}{\frac{99.586}{99.582}-1} + \frac{\frac{\log(7+15)}{\log(15)}-1}{\frac{99.594}{99.586}-1} + \cdots + \frac{\frac{\log(2+2+75+7+15)}{\log(2+75+7+15)}-1}{\frac{99.617}{99.609}-1}\right\}$$

$$= 7603$$

The ask order book slope for snapshot 1 is gentler than that for snapshot 2. A gentler slope indicates that market participants submit their orders over a wider range of quotes for a given volume, which shows a more diverse private opinion over the value of the Treasury note. Thus, the ask order book slope for snapshot 1 indicates a higher dispersion of beliefs among investors, while the ask order book slope for snapshot 2 shows a lower dispersion of beliefs.

4.2 Order Aggressiveness and Filtered Trade Imbalance

In order to examine the return predictability of trade imbalance based on informed trades, this thesis identifies the aggressive (informed) trades and estimates the trade imbalance by using aggressive trades. We consider trades with a higher degree of aggressiveness as a proxy for the informed trades. Abad and Rubia (2004) argue that the order aggressiveness is closely related to informed trading. Most aggressive orders are likely to be submitted by informed traders. The more aggressive the order is, the more information is conveyed.

This thesis ranks orders based on their degrees of aggressiveness. Aggressive traders are usually impatient to trade. Investors want to trade at any given price and demand a larger quantity than that available at the prevailing best quotes. However, investors with less aggressiveness demand a lower quantity than that available at the current best quotes. We define two types of orders according to different degrees of aggressiveness: **A1** is the most aggressive orders. In that case, investors are usually impatient to trade. They trade at the first tier and continue to trade in other tiers until they buy or sell their desired quantity. **A2** is the less aggressive orders. Traders using A2 orders are patient and conservative. They place orders at the first tiers, but do not continue to trade in other tiers.

Furthermore, we rank all the trades into four groups based on their trade size. The first group with the largest trade sizes is defined as the large category (L). The next group with the second and third largest trade sizes is defined as the medium category (M). The third group with small trade sizes is defined as the small category (S). Then, if a trader places A1 orders in a large category (L), we define the orders as **A1L**. Similarly, if A1 trades fall into the medium category (M) or small category (S), we define them as **A1M** and **A1S**, respectively.

Finally, we use **A1L** and **A1M** orders as a proxy for the informed trades. The trade imbalance **TIBA1** is defined as the buyer initiated trades of A1L and A1M minus seller initiated trades of A1L and A1M.

4.3 Price Impact of Trade Imbalance

The price impact coefficient is a popular measure of market liquidity (Fleming, 2003). Trade imbalance contains important information and has direct impact on the current price changes. Price impact coefficient measures the effect of trade imbalance on price changes. High price-impact is associated with low liquidity. Brandt and Kavajecz (2004) and Chordia et al. (2008) suggest that effect of trade imbalance on the prices is stronger when the liquidity is lower. We examine the price impact of the treasuries in the eSpeed electronic market and compare with the results in Fleming (2003), which examines the price impact of trade imbalance using GovPX data. We expect that the price impact of eSpeed data is lower than GovPX data, since the eSpeed electronic trading platform is a more liquid market. Similar to the previous studies (Chordia et al. 2008), we regress five-minute price changes on the trade imbalance within each five-minute interval.

The following regression measures the relationship between trade imbalance (TIB) and price changes for 2-year, 5-year, 10-year notes and 30-year bonds for the period from June 1, 2005 to May 30, 2008 during the U.S. trading hours between 8:00am ET to 5:00 pm ET. We divided the trading hours into 108 five-minute intervals. The price changes are calculated using the mid-quotes at the end of each five-minute interval. TIB is defined in two different ways (TIBNUM and RELTIBNUM). TIBNUM is the number of buyer-initiated trades minus the number of seller-initiated trades in five-minute interval. RELTIBNUM is the number of buyer-initiated trades minus the number of seller-initiated trades, divided by the total number of trades in five-minute interval. The model is defined as follows:

$$\Delta P_t = incercept + \phi TIB_t + \varepsilon_t, \qquad (9)$$

where coefficient ϕ indicate the price impact of trade imbalance on price changes. The results are presented in Table 24.

4.4 Daily Regression of Returns on Trade Imbalance and Order Book Imbalance

This section examines the information content of the daily trade imbalance and order book imbalance on the Treasury returns. Furthermore, we investigate how the macroeconomic announcements, informed trading and dispersion of beliefs among investors influence the informativeness of trade imbalance in predicting the U.S. Treasury returns. Chordia and Subrahmanyam (2004) find a positive relation between lagged daily imbalance and returns in the stock market, which reverses sign after controlling for the current imbalance. They argue that the negative relation between returns and lagged trade imbalance after controlling for the current trade imbalance is due to the fact that the effect of the current imbalance overweighs the impact of current trades that are auto-correlated with past trades.

The following model examines the information content of the trade imbalance estimated by aggressive (informed) trades only, which is denoted as **TIBA1** (explained in section

4.2). **TIBA1** represents the position that the informed traders take, which should be more informative for future returns. We expect that lagged **TIBA1** should be positively related to current returns even after controlling for the current trade imbalance.

The model in this section also controls for the current limit order book imbalance. As discussed in Glosten (1994), Beber and Caglio (2005), and Moshirian et al. (2009), limit order book contains information on prices. Moshirian et al. (2009) show that the slope of demand curve over the supply curve of the order book predicts short-term (30 minutes) returns. This thesis estimates the order book imbalance (**OIB**) in an alternative way. We select eight hourly spaced snapshots of the order book, at 8:30am, 9:30am, 10:30am, 11:30am, 12:30pm, 13:30pm, 14:30pm, and 15:30pm.

For each snapshot we have the trading volume for five tiers for the demand (bid) side: $v_1^B, v_2^B \dots, v_5^B$; and for the supply (ask) side: $v_1^A, v_2^A \dots, v_5^A$. s denotes the snapshots. Then order book imbalance for each snapshot is denoted as:

$$OIB^s = \sum_{\tau=1}^{5} v_\tau^B - \sum_{\tau=1}^{5} v_\tau^A \quad (s = 1,2 \dots 8) \qquad (10)$$

Then, the daily order book imbalance on day t is the sum of the eight OIB snapshots:

$$OIB_t = \sum_{s=1}^{8} OIB^s \qquad (11)$$

An example to illustrate how to calculate order book imbalance for each snapshot is given in the following table. The table shows bid and ask prices and quantities for five tiers.

	Ask Price	Quantity
tier 1	\$99	8
tier 2	\$100	7
tier 3	\$101	6
tier 4	\$102	5
tier 5	\$103	4
	Bid price	Quantity
tier 1	\$98	10
tier 2	\$97	9
tier 3	\$96	8
tier 4	\$95	7
tier 5	\$94	6

The order book imbalance is calculated as follows:

$$OIB^s = (10 + 9 + 8 + 7 + 6) - (8 + 7 + 6 + 5 + 4) = 10$$

In addition, the regression model also investigates how the dispersion of beliefs affects the return predictability of trade imbalance. We include the order book slope dummy AD_t to investigate how the predictability of daily trade imbalance varies for different degrees of dispersion of beliefs among investors. As we explain in section 4.1, daily order book slope (which is defined as $SLOPE_t$ in section 4.1 equation (8)) is a measure for the daily dispersion of beliefs among investors. The gentler the order book slope is, the more dispersion there is among investors. Therefore, we rank the daily order book slope for 400 macroeconomic announcement days. Then we divide those announcement days into 4, 5, and 6 groups according to the ranking. If the announcement day *t* belongs to the group with the lowest daily order book slope, then dummy AD_t equals to 1, otherwise 0. The model is defined as follows:

$$\begin{aligned} R_t = {} & \beta_0 + \beta_1 TIBA1_t + \beta_2\, OIB_t + \beta_3 * OIB_t * Ann_t \\ & + \beta_4 * TIBA1_t * AD_t + \beta_5 TIBA1_{t-1} + \beta_6 * TIBA1_{t-1} * AD_{t-1} + \varepsilon_t \end{aligned} \tag{12}$$

R_t is the log changes of the first and last mid-quotes of day t. $TIBA1_t$ is the trade imbalance estimated by aggressive (informed) trades on day *t*. OIB_t is order book imbalance on day t. Ann_t is a dummy variable which equals to 1 when there is a macroeconomic announcement on day t and 0 otherwise. AD_t is a dummy variable, which equals to 1 when the order book slope is in the bottom group (1/4, 1/5 or 1/6) on announcement days, and equals to 0 otherwise. We are interested in the sign of β_6 coefficient. If the trade imbalance estimated by informed trades on high dispersion announcement days predicts returns on the day following the announcement day, we expect β_6 to be significantly positive. This regression analysis is conducted for 2-year, 5-year, 10-year notes and 30-year bonds for the period from June 1, 2005 to May 30, 2008 during the U.S. trading hours (7:30 am to 5:30 pm ET).

4.5 Return Predictability of Trade Imbalance

In this section, we examine the return predictability of trade imbalance, without controlling for current trade imbalance. In addition, we examine the information content of the daily trade imbalance estimated by aggregate trades and daily trade imbalance estimated by informed trades. We estimate informed trades based on aggressive orders, defined in section 4.2. If aggressive orders represent the position that informed traders take, aggressive orders should be informative on future returns. Moreover, Jiang and Lo (2008) find that the highest group of PIT (probability of informed trading) is associated with the gentlest order book slope, which indicates that more dispersion of beliefs among investors is associated with more informed trading. Moshirian et al. (2009) argue that macroeconomic announcements that are hard to interpret induce a high dispersion of beliefs among investors, which offer advantages for the skilled traders who have private information. We expect that, during the macroeconomic announcement days with high dispersion of beliefs, daily trade imbalance estimated by informed trades predicts returns on the day following the announcement day. This regression analysis is conducted for 2-year, 5-year, 10-year notes and 30-year bonds for the period from June 1, 2005 to May 30, 2008 during the U.S. trading hours (7:30 am to 5:30 pm ET). We define the model as follows:

$$R_t = \beta_0 + \beta_1 TIB_{t-1} + \beta_2 TIBA1_{t-1} + \beta_3 TIB_{t-1} * AD_{t-1} + \beta_4 TIBA1_{t-1} * AD_{t-1} + \varepsilon_t \tag{13}$$

R_t is the log changes of the first and last mid-quotes of day t. TIB_{t-1} is the daily trade imbalance which is equal to buyer initiated trades minus seller initiated trades on day t-1. $TIBA1_{t-1}$ is the trade imbalance estimated by informed trades on day t-1. AD_{t-1} is a dummy variable, which is equal to 1 when the order book slope is in the bottom group (1/4, 1/5 or 1/6) on announcement days, and is equal to 0 otherwise. We are interested in the significance and sign of β_4 coefficient. We expect β_4 to be significantly positive if informed trade imbalance on announcement days with high dispersion of beliefs predicts returns on the day following the announcement day.

5. Descriptive Statistic and Results

5.1 Descriptive Statistic

This section examines the market liquidity for the Treasury market, which is traded in the eSpeed electronic platform for 2-year, 5-year, 10-year notes and 30-year bonds for the period from June 1, 2005 to May 30, 2008. We report different measures of the market liquidity for all the announcement days and non-announcement days, announcement days with high macroeconomic surprise and announcement days with high dispersion of beliefs among investors. Announcement days (400 days) are defined as those with morning or afternoon announcements. Non-announcement days (350 days) are those with no morning or afternoon announcements. Announcement days with high macroeconomic surprise are defined as 8:30am announcement days with top 30% macroeconomic surprise[12] (100 days). Announcement days with high dispersion of beliefs are those announcement days with daily order book slope[13] that is in the bottom 1/4 among all the announcement days (100 days). We report the p-values from t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. As discussed in section 2.4, order book slope should be a better measure of market uncertainty, since it directly captures the investors' opinions on the fair value of the asset while the macroeconomic surprise represents the uncertainty of the investors on the macroeconomic indicators' value. Thus, the descriptive statistics for the announcement days with high dispersion of beliefs should be more representative for the trading activity of the periods with high level of market uncertainty.

5.1.1 Trading Volume

This section presents the descriptive statistics for the unconditional and conditional daily trading volume. For the unconditional trading volume, we provide the statistics for daily trading volume for all announcement days and non-announcement days. For the conditional trading volume, we focus on the announcement days conditional on high macroeconomic surprise and high dispersion of beliefs among investors.

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[12] Surprise measure is defined in section 3.3, equation (2).
[13] Daily order book slope is specified in section 4.1, equation (8).

5.1.1.1 Announcement and Non-Announcement Days

Table 1 reports descriptive statistics on mean and median daily trading volume for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. The U.S. trading hours is shown to have a more liquid trading period than Tokyo and London trading hours. For 2-year notes, mean (median) daily trading volume is \$26485 (\$24929) million, while it is only \$412 (\$327) million and \$1701 (\$1514) million for the Tokyo and London trading, respectively. Moreover, the 2-year notes are shown to be the most actively traded bonds among the four treasury securities and the trading volume decreases with maturity. This finding is consistent with Fleming (2003), which conducts the analysis based on GovPX data and reports that 2-year notes is the most actively traded Treasury notes among the 2-year, 5-year and 10-year Treasury notes. It is also consistent with the results in Fleming and Mizrach (2009), which conduct the analysis based on data from BrokerTec electronic Platform and show that 2-year notes are the most actively traded Treasury notes and the trading volume decreases monotonically with maturity. In addition, Fleming (2003) reports the mean (median) trading volume of \$6810 (\$6670) million for the 2-year notes in the interdealer market during the U.S. trading hours. Compared to Fleming's results, the mean (median) daily trading volume of \$26485 (\$24929) million for 2-year notes in the eSpeed electronic market is dramatically greater. This finding provides supporting evidence that eSpeed electronic market is much more active than the GovPX interdealer market.

In addition, Table 1 indicates that daily trading volume significantly increases on announcement days during London and U.S. trading hours. The mean (median) daily trading volume for the 2-year notes increases from \$1537 (\$1346) million on non-announcement days to \$1701 (\$1514) million on announcements days during London trading hours. Both the mean and median tests show that the differences are significant at 5% level. The mean (median) daily trading volume for the 2-year notes increases from \$22079 (\$20124) million on non-announcement days to \$26485 (\$24929) million on announcements days during U.S. trading hours, and both the mean and median tests show that the differences are significant at all levels. This finding is consistent with the previous literature that trading volume increases on announcement days (Green et al., 2001; Dungey et al., 2008). When there is a public information arrival, the market (liquidity traders and informed traders) reacts to the new information by increasing the trading volume.

5.1.1.2 Announcement and Non-Announcement Days Conditional on Surprise and Dispersion of Beliefs

In addition, we compare the mean and median daily trading volume on announcement days with top 30% macroeconomic surprises to the ones on non-announcement days in Table 2. The statistics shows that the average daily trading volume significantly increases for the 2-year, 5-year, 10-year notes and 30-year bonds on announcement days with top 30% macroeconomic surprises during the U.S. trading hours. Both the mean and median tests show that the difference between the announcement days with top 30% macroeconomic surprises and the non-announcement days are significant at all levels for the U.S. trading hours, but it is not significant for the Tokyo and London trading hours. The macroeconomic surprises reflect the market uncertainty in response to the announcements. Kim et al (2004) argue that it may not be the act of releasing information to the market that is important, but the extent to which the actual announcement differs from the expected value which determines the response of the market to the new information. Balduzzi (2001) finds that the information role of trading is associated with the surprise component of the announcements and the precision of the public information. Thus, during the announcement days with high macroeconomic surprises, market uncertainty is higher, which offers advantages to the informed traders who have skills to interpret the announcements better. In turn, with short-lived information, informed traders speculate and contribute to the increase in trading volume following the announcements.

Finally, Table 3 shows the mean and median daily trading volume on the announcement days with high dispersion of beliefs and on non-announcement days. The statistics show that, on the announcement days with high dispersion of beliefs, average daily trading volume increases significantly for the 2-year and 5-year notes during the Tokyo and

London trading hours, and for the 2-year, 5-year and 10-year notes during the U.S. trading hours. Both the mean and median tests show that the difference is significant at all levels. For example, for the 2-year notes during the U.S. trading hours, the mean daily trading volume increases by 46% ($\frac{32336-22079}{22079}$) on the announcement days with high dispersion of beliefs compared to the non-announcement days.

Naes and Skjeltorp (2006) also show that trading volume and volatility is higher when the dispersion of beliefs among investors is greater in the stock market. They suggest that the increased trading volume can be attributed to both uninformed traders and informed investors. The fact that volume significantly increases during Tokyo and London trading (i.e., before the release of macroeconomic indicators) provide supporting evidence that during announcement days with high dispersion of beliefs skilled traders might speculate on the announcements that are hard to interpret and increase trading volume before the announcements.

5.1.2 Trading Frequency

This section presents the descriptive statistics for unconditional and conditional daily trading frequency. For the unconditional trading frequency, we provide statistics for announcement and non-announcement days. For the conditional daily trading frequency, we focus on the announcement days conditional on high macroeconomic surprise and high dispersion of beliefs among investors.

5.1.2.1 Announcement and Non-Announcement Days

Table 4 reports descriptive statistics on the daily number of trades for the indicated on-the –run securities for Tokyo, London and U.S. trading hours, for both announcement and non-announcement days. The results show that 10-year and 5-year notes are most frequently traded among the four securities. This finding is consistent with Fleming (2003), which conducts the analysis based on GovPX data and reports that 10-year and 5-year notes are the most frequently traded notes among the 2-year, 5-year and 10-year Treasury notes. The results show that daily number of trades increases significantly on announcement days for the 2-year, 5-year, 10-year notes and 30-year bonds during the U.S. trading hours. Both the mean and median tests show that the increase is significant.

This finding indicates that market reacts to macroeconomic announcements by increasing the trading frequency during the U.S. trading hours, which is consistent with Dungey et al (2008) that reports an increase in trading frequency after the macroeconomic announcements.

5.1.2.2 Announcement and Non-Announcement Days Conditional on Surprise and Dispersion of Beliefs

In addition, we compare the daily number of trades on announcement days with the top 30% macroeconomic surprises to the ones on non-announcement days in Table 5. The statistics show that the average daily number of trades increases significantly for the 2-year, 5-year, 10-year notes and 30-year bonds on announcement days with top 30% macroeconomic surprises during the U.S. trading hours. However, the increase is not apparent in the Tokyo and London trading hours.

Nevertheless, Table 6 shows that, on the announcement days with high dispersion of beliefs, daily number of trades increases significantly for the 2-year, 5-year and 10-year notes during the Tokyo and London trading hours, and for the 2-year, 5-year, 10-year notes and 30-year bonds during the U.S. trading hours. The increase in Table 6 is more dramatic than the increase on announcement days with top 30% macroeconomic surprise in Table 5. For example, for the 2-year notes during U.S. trading hour, the mean daily trading frequency increases by $111\%(\frac{1857-879}{879})$ on the announcement days with high dispersion of beliefs compared to the non-announcement days. This finding indicates that during announcements days with high dispersion of beliefs, liquidity traders and skilled (informed) traders in the U.S. Treasury market react to the public information stronger by increasing the number of trades when the information is harder to interpret.

5.1.3 Trade Size

This section presents the descriptive statistics for the unconditional and conditional daily trade size. For the unconditional trade size, we provide the statistics for daily trade size for all announcements days and non-announcement days. For the conditional daily trade size, we focus on the announcement days with high macroeconomic surprises and high dispersion of beliefs among investors.

5.1.3.1 Announcement and Non-Announcement Days

Table 7 reports descriptive statistics on mean daily trade sizes for the indicated on-the – run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. We observe that the mean (median) daily trade size decreases monotonically with maturity, from $29.4 ($29.6) million for the 2-year notes to $3 (3) million for the 30-year bond, which is also consistent with the findings in Fleming (2003). The U.S. trading hour is shown to have a larger trade size than the Tokyo and London trading hours. Comparing announcement days with non-announcement days, the mean and median tests show that daily trade sizes on announcement days increase significantly only for the five-year and ten-year notes during the U.S. trading hours.

5.1.3.2 Announcement and Non-Announcement Days Conditional on Surprise and Dispersion of Beliefs

Table 8 reports mean and median daily trade sizes on the 8:30 am announcement days with top 30% macroeconomic surprises and on non-announcement days. The mean test shows that, during Tokyo trading hours, the trade size for 5-year notes decreases significantly at 0.05 levels on the 8:30am announcement days with top 30% macroeconomic surprises. The median test shows that, during Tokyo and U.S. trading hour, trade size for 10-year notes decreases significantly at 5% level on the 8:30am announcement days with top 30% macroeconomic surprises.

However, Table 9, which reports the mean and median daily trade sizes on the announcement days with high dispersion of beliefs and on the non-announcement days, indicates that the mean and median daily trade sizes decrease significantly on the announcement days. Both the mean and median tests show that the decrease is significant for 2-year, 5-year, 10-year notes and 30-year bonds during all the trading hours. For example, for the 2-year notes during U.S. trading hours, the mean daily trade size decreases by $36\%(\frac{18-28}{28})$ on the announcement days with high dispersion of beliefs compared to the non-announcement days.

Pasquariello and Vega (2007) suggest that periods of greater dispersion of beliefs among market participants are accompanied by more cautious trading activity. Therefore, we believe that during the periods of greater dispersion of beliefs, the investors are more cautious and more likely to place smaller orders.

5.1.4 Quote Size

This section presents the descriptive statistics for unconditional and conditional daily quote sizes. For the unconditional daily quote sizes, we provide the statistics for daily quote size for all announcements days and non-announcement days. For the conditional daily quote sizes, we focus on the announcement days with high macroeconomic surprises and high dispersion of beliefs among investors.

5.1.4.1 Announcement and Non-Announcement Days

Table 10 reports descriptive statistics for mean daily quote sizes for the indicated on-the – run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Quote sizes are the quoted sizes for the best bid and offer prices in the electronic market. The mean daily figure is calculated with both bid and offer quantities. The results show that daily quote sizes decrease monotonically with maturity, from \$267.3 (\$260.6) million for the 2-year notes to \$6 (5.5) million for the 30-year bond. The U.S. trading hour is shown to have larger trade size than the Tokyo and London trading hours. However, comparing announcement days with non-announcement days, the mean and median tests show that daily trade sizes do not vary significantly between those two periods.

5.1.4.2 Announcement and Non-Announcement Days Conditional on Surprise and Dispersion of Beliefs

Table 11 reports the mean and median daily quote sizes on announcement days with top 30% macroeconomic surprises and on non-announcement days. It is shown that the mean daily quote sizes do not significantly vary between those two periods. Nevertheless,

Table 12, which reports the mean and median daily quote sizes on the announcement days with high dispersion of beliefs and on non-announcement days, indicates that the mean daily quote sizes decrease significantly for the announcement days. Both the mean and median tests show that the decrease is significant for 2-year, 5-year, 10-year notes and 30-year bonds during the Tokyo, London and U.S. trading hours at all levels. For example, for the 2-year notes during U.S. trading hours, the mean daily quote size decreases by $69\%(\frac{86-279}{279})$ on the announcement days with high dispersion of beliefs compared to the non-announcement days. As mentioned earlier, Pasquariello and Vega (2007) suggest that periods of greater dispersion of beliefs among market participants are accompanied by more cautious trading activity. Therefore, we believe that during the periods of greater dispersion of beliefs, the investors are more cautious and reduce quotes sizes.

5.1.5 Absolute Net Numbers of Trades

This section presents the descriptive statistics for unconditional and conditional daily absolute net number of trades. For the unconditional daily absolute net number of trades, we provide the statistics for daily absolute net number of trades for all announcements days and non-announcement days. For the conditional daily absolute net number of trades, we focus on the announcement days with high macroeconomic surprises and high dispersion of beliefs among investors.

5.1.5.1 Announcement and Non-Announcement Days

Table 13 reports descriptive statistics on daily absolute net number of trades for the indicated on-the –run securities for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. The daily absolute net number of trades is equal to the average of daily absolute net number of trades (absolute value of the buyer initiated trades minus the seller initiated trades on each day). The results show that daily absolute net number of trades is highest for the 5-year notes and smallest for the 30-year bond. The table shows that absolute net number of trades is higher during the U.S. trading hours than the Tokyo and London trading hours. Judged from the mean and median values, daily absolute net number of trades do not vary significantly between announcement and non-announcement days.

5.1.5.2 Announcement and Non-Announcement Days Conditional on Surprise and Dispersion of Beliefs

Table 14 reports the mean daily absolute net number of trades on announcement days with top 30% macroeconomic surprises and on non-announcement days. It is shown that the daily absolute net number of trades does not vary significantly between those two periods. However, Table 15 shows that mean daily absolute net number of trades increase for the announcement days with high dispersion of beliefs for the 2-year and 5-year notes. The increase is more obvious for Tokyo and U.S. trading hours. For example, for the 2-year notes during U.S. trading hour, the mean daily absolute net number of trades increase by 30%($\frac{57-44}{44}$) on the announcement days with high dispersion of beliefs compared to the non-announcement days.

Chordia and Subrahmanyam (2004) suggest that a large trade imbalance prior to an informational event indicates informed trading, while large trade imbalance following the information event may reveal a change in investors' expectations. Moreover, Jiang and Lo (2008) find that the highest group of PIT (probability of informed trading) is associated with the period of high dispersion of beliefs. Since 2-year and 5-year notes are most actively traded in the Treasury market, skilled (informed) traders might speculate using 2-year and 5-year notes before or after the macroeconomic announcements when the announcements are hard to interpret. Thus, we believe that high absolute net number of trades in Tokyo and London signals informed trading for the 2-year and 5-year notes during the announcement days with high dispersion of beliefs.

5.1.6 Daily Bid-Ask Spreads

This section presents the descriptive statistics for unconditional and conditional daily bid-ask spreads. For the unconditional daily bid-ask spread, we provide the statistics for the daily bid-ask spread for all announcements days and non-announcement days. For the conditional daily bid-ask spreads, we focus on the announcement days with high macroeconomic surprises and high dispersion of beliefs among investors.

5.1.6.1 Announcement and Non-Announcement Days

Table 16 reports descriptive statistics on daily mean bid-ask spreads for the indicated on-the -run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. It is shown in the table that the longer the time to maturity of a Treasury security is, the wider the bid-ask spread is. Fleming (2003) suggests that the bid-ask spread is a useful measure for Treasury market liquidity. The wider the spread is, the lower the market liquidity is. It is suggested in the results that 2-year notes are the most liquid securities and 30-year bonds is the least liquid.

The table shows that the bid-ask spreads decrease from Tokyo trading hours to London hours and then to U.S. hours, indicating that the U.S. trading is more liquid than Tokyo and London trading. However, both the mean and median tests show that daily bid-ask spreads do not vary significantly between the announcement and non-announcement days.

5.1.6.2 Announcement and Non-Announcement Days Conditional on Surprise and Dispersion of Beliefs

Table 17 reports the mean and median daily bid-ask spreads on announcement days with top 30% macroeconomic surprises and on the non-announcement days. Mean daily bid-ask spread does not display significant difference between the announcement days with top 30% macroeconomic surprises and non-announcement days. However, Table 18 shows that the bid-ask spreads for all the maturities considered increases on the announcement days with high dispersion of beliefs during all the trading hours. The mean test shows that the increase is significant at all levels for the 2-year, 5-year, 10-year notes and 30-year bonds during the London and U.S. hour, and it is significant for the 30-year bonds during the Tokyo hours. The median test shows that the increase is significant at all levels for the 2-year, 5-year, 10-year notes and 30-year bonds for all the trading hours. The increase is more obvious for Tokyo and U.S. trading hours. For example, for the 2-year notes during U.S. trading hour, mean daily bid-ask spread increases by

5% ($\frac{0.00868-0.00826}{0.00826}$) on the announcement days with high dispersion of beliefs comparing to the non-announcement days. Kim and Verrecchia (1994) suggest that the market liquidity decreases when there is a higher dispersion of beliefs among investors, resulting in the widening of spreads. They mention that when the number of informed trades increases, market makers may suffer an informational disadvantage, which triggers them to increase the bid-ask spreads. Thus, we believe that, the widening spread for all the maturities during the announcements days with high dispersion is attributed to the decrease in market liquidity and increase in information asymmetry.

5.1.7 Intraday Bid-Ask Spreads

This section presents the descriptive statistics for the unconditional and conditional intraday bid-ask spreads. The reported bid-ask spread is the actual mean proportional spread[14] times 10^4. For the unconditional intraday bid-ask spread, we provide the statistics for all 8:30 am announcement days and non-announcement days. For the conditional intraday bid-ask spread, we focus on the announcement days with high macroeconomic surprises and high dispersion of beliefs among investors.

5.1.7.1 Announcement and Non-Announcement Days

Table 19 presents the mean bid-ask spreads for one minute intervals between 8:25 am and 8:40 am. The bid-ask spread is the mean proportional spread, which equals to the differences between the best bid and ask prices divided by the mid-quote. The reported bid-ask spread is the actual mean proportional spread times 10^4. We report the p-values from the t-statistics to compare means for announcement and non-announcement days assuming unequal variance. As is shown in Table 19, the spread starts to widen 4 minutes before the announcements for the 2-year and 5-year notes, 2 minutes before the announcements for the 10-year notes and 5 minutes before the announcements for the 30-year bond. The spread reaches a peak between 8:29 am and 8:30 am for all the indicated Treasury securities. Then the bid-ask spreads revert to normal values 1 to 4 minutes after the 8:30 am announcements. The widening of the spreads lasts longer for the 30-year bonds among the four securities, which is four minutes. Our findings are consistent with

[14] Mean proportion spread is equal to the bid-ask spread divided by the mid-quote.

the pervious literature. Green (2004) conducts the analysis based on GovPX data and finds that the average quoted spreads are larger than usual before the economic news release and decrease afterwards. Balduzzi et al (2001) also conduct the study based on GovPX data and show that the bid-ask spreads widen exactly at the time when the announcement is made and reverts to normal levels after five to fifteen minutes. They explain that bid ask spreads widen around announcements because bid-ask spread is the price of an "option to trade" offered by the market maker to traders. As the macroeconomic announcement increases the volatility in the Treasury market, the value of option to trade increases, which is reflected by a widening of the spread. When compared to our results, the widening of the spreads lasts longer in the case of GovPX because the trading is carried out in an interdealer market, which is less liquid than the eSpeed electronic market. We believe that the widening of the spread before the announcements is due to the increased market uncertainty before the announcements. The persistence in wide spreads after the announcements can be explained by the increased information asymmetry.

5.1.7.2 Announcement and Non-Announcement Days Conditional on Surprise and Dispersion of Beliefs

Table 20 reports mean bid-ask spreads for one minute intervals between 8:25 am and 8:40 am for 8:30 am announcement days with top 30% macroeconomic surprises and non-announcement days. The spread displays similar patterns as it is shown in Table 19. However, Table 21, which reports the mean bid-ask spreads for one minute intervals for the announcement days with high dispersion of beliefs and non-announcement days, displays a significantly widening of spreads from 8:25 am to 8:40 am. The widening reaches a peak between 8:29 am and 8:30 am for all Treasury notes and bonds. For example, for the 2-year notes during the 1 minute interval from 8:29 am to 8:30 am, mean bid-ask spread increases by $114\%(\frac{1.8511-0.8654}{0.8654})$ on the announcement days with high dispersion of beliefs compared to the non-announcement days.

During the announcement days with high dispersion of beliefs, the announcements are not easy to interpret by all the investors, which induce an information asymmetry in the market and lead to a decrease in liquidity. Moreover, the announcements, which are hard to interpret, offer advantages to the skilled traders. As the number of informed traders increase, market makers may suffer an informational disadvantage, which trigger them to increase the bid-ask spreads.

5.1.8 Order Book Slope Statistics

Summary statistics for daily order book slope for 2-year, 5-year, 10-year notes and 30-year bonds are shown in Table 22. The sample period is from June 1, 2005 to May 30, 2008 during the U.S. trading hours. To calculate the ask, bid and order book slopes, we apply a similar method to the one shown in section 4.1. The difference is that we estimate the slope based on 20 snapshots instead of 8 snapshots. Here, we divide the U.S. trading hours from 7:30am to 5:30pm into 20 half-hour intervals. At the end of each interval, we calculate the ask slope, bid slope and order book slope using the method in section 4.1.[15] The relative slope is calculated by the relative slope of demand side over supply side.[16] If macroeconomic announcements fall into an interval, we regard these periods as announcements periods, which is the *Ann* period in the table. Otherwise, intervals are non-announcement periods, which is the *Non-Ann* period in the in the table.

Table 22 reports the mean statistics for the ask slope, bid slope, order book slope and relative slope for all periods, non-announcement periods and announcement periods. The statistics are the actual statistics multiplied by 10^{-3}. The average order book slope for the sample period is 25.14 for 2-year notes, and decline to 17.64 for 5-year note, 9.06 for 10-year note, and 3.89 for the 30-year bond. The lower order book slope indicates higher dispersion of beliefs among investors. The result implies that the longer the maturity of the Treasury securities are, the more dispersion of beliefs about the value there is. The reason is that when the maturity increases, the uncertainty increases, then the dispersion of beliefs increases subsequently. The bid and ask slope display similar patterns. However, the relative slope is similar for the four Treasury securities. Moreover, the ask

[15] Ask slope corresponds to SE_t^s, bid slope corresponds to DE_t^s, and order book slope corresponds to $SLOPE_t^s$ in section 4.1.

[16] Relative Slope can be expressed as $\frac{DE_t^s}{SE_t^s+DE_t^s}$

slope, bid slope and order book slope are larger for the announcement periods than the non-announcement periods.

This result seems to provide supporting evidence that macroeconomic releases reduce the dispersion of beliefs among the investors. The public news arrivals may reduce the market uncertainty and information asymmetry among investors on average. However, if the macroeconomic announcements are not easy to interpret by the investors, the dispersion of beliefs may increase as implied by the previous results in this thesis and the results in Table 23.

Table 23 presents the summary statistics for the order book slope for the announcement periods with low forecast range (bottom 20%) and for those with high forecast range[17](top 20%). The sample period is from May 31, 2007 to May 30, 2008 during the U.S. trading hours.[18] The table shows that the ask slope, bid slope and order book slope are lower for the announcement periods with high forecast range than those with low forecast range, indicating that higher dispersion of beliefs is associated with higher forecast range. Since forecast range captures the degree of heterogeneity in the interpretation of the macroeconomic news, the results in this table imply that the release of hard-to-interpret public information increases market uncertainty and information asymmetry.

5.2 Price Impact of the Trade Imbalance

Based on the eSpeed Treasury data, we examine the price impact of the trade imbalance in equation (9). Table 24 reports the price impact coefficients for the 2-year, 5-year, 10-year notes and 30-year bonds for the period from June 1, 2005 to May 30, 2008 during the U.S. trading hours. The price impact coefficient is positive and significant for all the maturities. Panel A presents the results for TIBNUM, which is the number of buyer-initiated trades minus the number of seller-initiated trades cumulated over the 5-minute interval. The price impact coefficient of the 2-year notes is 0.000973 and adjusted R^2 is 0.1159. However, in Fleming (2003), which conducts the analysis based on GovPX data, the price impact coefficient is 0.0465 and adjusted R^2 is 0.322 for the 2-year note. Since

[17] Forecast range is specified in section 3.4, equation (3) and equation (4).
[18] The forecast range statistic is only available from May 31, 2007 to May 30, 2008.

higher price-impact is associated with lower liquidity, the different results between this thesis and Fleming (2003) indicate that eSpeed electronic market is much more liquid than the interdealer GovPX market. Moreover, the price impact coefficient increases with maturity, which is smallest for the 2-year notes and largest for the 30-year bond. These results indicate that the market liquidity decrease monotonically from the 2-year notes to 30-year bond. In addition, the adjusted R^2 is highest for 10-year notes and smallest for 30-year bond, which implies that the trade imbalance of 10-year notes explains more of the price changes while 30-year bonds' trade imbalance explains less of the price changes.

Panel B reports the results for RELTIBNUM, which is the number of buyer-initiated trades minus the number of seller-initiated trades, divided by the total number of trades. Consistent with Panel A, the price impact coefficient for 2-year notes is the smallest and the coefficient for 30-year bonds is the largest. Also, the adjusted R^2 is highest for 10-year notes and smallest for 30-year bond. The adjust R^2 statistic is higher in Panel A than in Panel B, which indicates that TIBNUM has a higher explanatory power for price changes than RELTIBNUM.

5.3 Daily Regression of Returns on Trade Imbalance and Order Book Imbalance

Table 25 presents the results for equation (12). The results are for 2-year, 5-year, 10-year notes and 30-year bonds for the period from June 1, 2005 to May 30, 2008 during the U.S. trading hours from 7:30am to 5:30pm. Panel A shows the regression results when AD_t dummy is equal to one for the announcement days with the bottom 1/4 order book slope. β_1 is positive and significant at all levels for all the maturities, which implies that the current trade imbalance estimated by informed trades is positively and significantly related to prices changes. β_2 is positive and significant at 1% level for 2-year notes, and significant at 5% level for other maturities. This finding is consistent with the previous literature (Glosten 1994; Beber and Caglio 2005; Moshirian et al 2009), which shows that limit order book contains information on prices. However, β_2 is smaller than β_1 for all the maturities, which provides evidence that current trade imbalance contains more information on returns than the current order book imbalance. β_3 reports the impact of the current order book imbalances on the returns during the announcement days, which is positive for the 2-year, 5-year and 10-year notes, but negative for the 30-year bond, all of them are not significant though. β_4 reports the impact of current trade imbalance estimated by informed trades on the return, which is positive for the 2-year, but negative for 5-year, 10-year notes and 30-year bond, all of them are not significant. β_5 measures how the lagged trade imbalance estimated by informed trades predicts returns. The coefficient is negative for 2-year, 5-year and 10-year notes, and positive for the 30-year bonds, and it is only significant for the 2-year note.

However, the coefficient β_6 is positive and significant for all the maturities, except for the 30-year bond. β_6 is the coefficient that we are interested in, which examines the return predictability of the trade imbalance(estimated by informed trades) during the announcements with high dispersion of beliefs among investors. This finding provides supporting evidence that the aggressive orders capture the private information and is more informative in predicating returns.

The results are consistent with Abad and Rubia (2004), which suggest that aggressive orders are associated with informed trading process. During the days with high dispersion of beliefs among investors, public information is not easy to interpret by all investors, and only the skilled traders can extract private information from the public information (Moshirian et al. 2009). In this case, the prices do not adjust to public information immediately and it may take time for the prices to fully reflect the public information. Therefore, during the announcements days with high dispersion of beliefs among investors, the trade imbalance estimated by informed trades can significantly predict returns on the following day.

Panels B and C show the regression results when AD_t dummy is equal to one for the announcement days with bottom 1/5 and 1/6 order book slope, respectively. The coefficients display similar patterns as they are in Panel A. However, β_6 is larger and more significant in Panel C than in Panel A and Panel B for 2-year and 5-year notes. This finding implies that higher dispersion of beliefs among investors contributes to a stronger return predictability of trade imbalance estimated by informed trades.

5.4 Return Predictability of Trade imbalance

In this section, we examine the return predictability of trade imbalance without controlling for the current trade imbalance. Table 26 presents the results for equation (13). The results are for 2-year, 5-year, 10-year notes and 30-year bonds for the period from June 1, 2005 to May 30, 2008 during the U.S. trading hours from 7:30am to 5:30pm. Panel A shows the regression results when AD_t dummy is equal to one for the announcement days with bottom 1/4 order book slope. β_1 is negative for 2-year notes and positive for 5-year notes, 10-year notes and 30-year bond. However, it is only significant for the 2-year notes. TIB_{t-1} is calculated by the aggregate orders, which does not differentiate informed trades from liquidity trades. Therefore, there is noise created by the liquidity traders, which reduce the return predictability of the trade imbalance. β_2 reports the return predictability of the trade imbalance estimated by informed trades. It is negative for the 2-year, 5-year, and 10-year notes and positive for 30-year bond, but it is only significant for the 2-year note. The negative sign and insignificance of β_2 may be because during the days without public news arrival, there isn't material information for the skilled traders. β_3 is not significant for all maturities. However, β_4 is positive and significant for all maturities, except for 30-year bond. β_4 measures the return predictability of the trade imbalance estimated by informed trades on announcement days when the disagreement about the bond value is in the top 1/4. This finding also confirms the results in Table 25 that aggressive orders capture the private information and is more informative in predicating returns during the announcement days with high dispersion of beliefs among investors. Therefore, the empirical results may show that there may be profitable opportunities on the announcement days when macroeconomic announcements are hard to interpret.

Panels B and C show the regression results when AD_t dummy is equal to one for the announcement days with the bottom 1/5 and 1/6 order book slope, respectively. The coefficients display similar patterns as they are in Panel A. Again, β_4, which measures the return predictability of informed trades during the announcements with high dispersion of beliefs among investors, is larger and more significant in Panel C than in Panel A for 2-year and 5-year notes. This finding also implies that the higher the dispersion of beliefs among investors is, the stronger the return predictability of trade imbalance estimated by informed trades is. These results indicate that the dispersion of beliefs increase the return predictability of the trade imbalance at daily level, which can also be explained by the previous literature (Jiang & Lo 2008) that higher dispersion of beliefs among investor is related to higher probability of informed trading.

6. Trading Strategy

In the previous section, we show that trade imbalance (based on informed trades) on the announcements days with high dispersion of beliefs predicts returns on the following day. Based on the regression results, we develop a trade-imbalance based trading strategy conditional on informed trading and announcements with high dispersion of beliefs. Since the 30-year bonds are not frequently traded in the market, we develop the trading strategy only for the 2-year, 5-year and 10-year notes. Chordia and Subrahmanyam (2004) develop a trading strategy in stock market. They buy a share at the opening ask and sell at the closing bid if the trade imbalance is positive during the previous day. The trades are reversed if the previous day's imbalance was negative. They show that their trading strategy yields a statistically significant positive daily returns for the entire sample. This thesis develops a trading strategy that is similar to the one developed by Chordia and Subrahmanyam (2004). We expect that our modified trading strategy will provide more significant results since we condition our trading on the dispersion of beliefs and aggressive (informed) trades.[19]

6.1 Trade-imbalance Based Trading Strategy Conditional on Dispersion of Beliefs

This section presents the results from the trade-imbalance based trading strategy conditional on dispersion of beliefs. The returns are from a trading strategy that is based on low slope days (the days with order book slope of 10%, 15%, 20%, 25% or 30% lower than the average of previous 365 days). On those days with high dispersion of beliefs, if the trade imbalance is positive, we buy(sell) at the opening ask(bid) quote and sell(buy) at the closing bid(ask) quote in the following day. Return is calculated as the log changes of the first and last quotes of that day and it is reported in percentage points in the table. Table 27 reports the average returns over the period from June 1, 2005 to May 30, 2008 for the 2-year, 5-year and 10-year notes based on this trading strategy. t- Statistics are in parentheses.

[19] Chordia and Subrahmanyam(2004) condition their trades on the level of surprise in the macroeconomic announcements; however, surprise may not be a good measure of dispersion of beliefs as discussed in the text.

Panel A in Table 27 presents the average returns based on the trading strategy. In Panel A, trade imbalance is calculated with the aggregate trades without differentiating the informed trades from the liquidity trades. As it is shown in the table, such a strategy yields positive returns only for the 5-year notes when the previous day's order book slope is 15%, 20%, 25% or 30% lower than the average of last 365 days, though the returns are not significant. However, in Panel B, where trade imbalance is calculated by the informed trades only, the trading strategy yields more positive returns for all the indicated securities, but the positive return is only significant for 10-year notes when the previous day's order book slope is 20% lower than the average of the previous 365 days. For example, for the 10-year note, when we buy (sell) at the opening quote and sell (buy) at the closing quote if the previous day's trade imbalance is positive (negative) and order book slope is 20% lower than the average of previous 365 days, the strategy yields a significant daily average returns of 0.144%. Compared to Panel A, trading strategy in Panel B yields more positive returns, which, to some degree, demonstrates that aggressive trades are more informative on the future returns during the days with high dispersion of beliefs among investors. However, the results in this table are not significantly and positively different from zero.

6.2 Trade-Imbalance Based Trading Strategy Conditional on Dispersion of Beliefs and Announcement Days

This section shows the trade-imbalance based trading strategy conditional on dispersion of beliefs and macroeconomic announcement days. Different from section 6.1, we develop the trading strategy based on the days with macroeconomic announcements only instead of all days.

Table 28 reports the average returns over the period from June 1, 2005 to May 30, 2008 for the 2-year, 5-year, and 10-year notes. The returns are from the following trading strategy: we buy or sell (i) if the previous day is an announcement day, and (ii) if the order book slope on the previous announcement day is lower (10%, 15%, 20% 25% or 30% lower) than the average slope of previous 365 announcement and non-announcement days. During those low slope announcement days, if the imbalance is positive (negative), we buy (sell) at the opening ask (bid) quote and sell (buy) at the closing bid (ask) quote on the next day. Return is the log changes of the first and last quotes of that day and it is in percentage points. t- Statistics are in parentheses.

Panel A in Table 28 presents the average returns based on the trading strategy conditional on dispersion of beliefs and announcement days. In this Panel, trade imbalance is calculated with the aggregate trades without differentiating the informed trades from the liquidity trades. As it is shown in the table, generally, such a strategy yields more negative returns. For the 2-year note, it yields significantly negative returns when the announcement days' order book slope is 10% and 15% lower than the average slope of the previous 365 days.

Panel B in Table 28 reports the average returns based on the trading strategy conditional on aggressive (informed) trades, dispersion of beliefs and announcement days. In this Panel, trade imbalance is calculated with informed trades only. Compared to Panel A, trading strategy in Panel B yields more positive returns, which confirms the finding in the previous section that aggressive trades are more informative on the future returns during the days with high dispersion of beliefs among investors. The returns are significantly positive for the 2-year notes when the announcement days' order book slope is 25% or 30% lower than the average slope of previous 365 days. For the 2-year and 5-year notes, we can see that the higher the degree of dispersion on announcement days is, the higher and more significantly positive the returns for the Treasury notes are. This finding implies that the dispersion of beliefs among investors is associated with the informed trading and return predictability of the trade imbalance.

Fleming (1997) finds that the transaction cost is $39 per $1 million of bonds in the GovPX markets. However, Mizrach and Neely (2006) show that the transaction cost fallen by more than 90% to $2.5 per $1 million of bonds in the eSpeed markets. Based on our trading strategy, it yields daily average returns of 0.083% for the 2-year notes when the previous day is an announcement day and the order book slope is 30% lower than the average slope of the previous 365 days. Therefore, for $1 million of 2-year note, the strategy yields \$830 profit (\$1 million*0.083%). After subtracting the trading cost from the gross profit, we have the net profit of \$827.5(\$830-\$2.5).

6.3 Trade-Imbalance Based Trading Strategy Based on the Method in Chordia and Subrahmanyam (2004)

In this section, we follow the trading strategy of Chordia and Subrahmanyam (2004), which find significant average daily returns in the stock market. The average return is calculated from a strategy that buys a share at the opening ask and sells at the closing bid if the trade imbalance is positive during the previous day. The trades are reversed if the previous day's imbalance was negative.

Table 29 reports the average returns over the period from June 1, 2005 to May 30, 2008 for the 2-year, 5-year and 10-year notes. The returns are from (i) the trading strategy that buys (sells) if the previous day's trade imbalance is positive (negative), or (ii) a trading strategy that buys (sells) if the trade imbalance is positive (negative) and large (more than one or two standard deviation from zero). If we buy (sell), we buy (sell) at the opening ask (bid) quote and sell (buy) at the closing bid (ask) quote. Return is the log changes of the first and last quotes of that day and it is in percentage points. t- Statistics are in parentheses.

In Panel A, the trade imbalance is calculated by the aggregate trade. It is shown in the table that the strategy yields negative returns for the 2-year, 5-year and 10-year notes for all the indicated degrees of trade imbalance, and the negative returns are significant for the first strategy (TIB positive or negative) in the case of 2-year notes. In Panel B, the trade imbalance is calculated by the aggressive (informed) trades only. Similar to Panel A, the average daily returns for the 2-year, 5-year and 10-year notes are all negative for all the indicated degrees of trade imbalance. The negative returns are significant for the first strategy (TIB positive or negative) in the case of 2-year and 5-year notes. This finding implies that the trading strategy in Chordia and Subrahmanyam (2004) may not be suitable for the Treasury market. Our trade-imbalance based trading strategy conditional on dispersion of beliefs and announcement days seems to provide higher returns in the U.S. Treasury market.

7. Conclusions

In this thesis we investigate how informed trading, macroeconomic announcements and dispersion of beliefs affect the return predictability of trade imbalance using the eSpeed U.S. Treasury data for the period from June 2005 to May 2008 for the 2-year, 5-year, 10-year notes and 30-year bonds.

For preliminary analysis, this thesis provides statistics for the trading activities of the U.S. Treasury notes and bonds. The statistics show that trading volume, trading frequency, bid-ask spread and daily absolute number of trades increase, while trade size and quote size decrease before the macroeconomic release. To some degree, the descriptive statistics imply that there are more speculations and cautious trading during the announcement days with high dispersion of beliefs among investors. Moreover, we conduct a simple regression analysis and estimate the price impact coefficient for the 2-year, 5-year, 10-year notes and 30-year bonds using eSpeed U.S. Treasury data. The results show that the price impact coefficient increases monotonically with maturity, which is smallest for the 2-year notes and largest for the 30-year bonds, indicating that 2-year notes are the most liquid T-notes in the eSpeed U.S. Treasury market. Compared to Fleming (2003) that uses GovPX data, the price impact coefficient is much smaller in this thesis, implying that eSpeed electronic market is much more liquid than the interdealer market.

Furthermore, this thesis differentiates liquidity trades from informed trades and estimates trade imbalance based on informed trades only. Motivated by Abad and Rubia(2004), which show that order aggressiveness is closely related to informed trading, we use the aggressive trades as a proxy for informed trades. In addition, in order to examine the effect of the dispersion of beliefs on the return predictability of trade imbalance, we use daily order book slope as a proxy for dispersion of beliefs. The regression results show that, on the macroeconomic announcement days with high dispersion of beliefs, daily trade imbalance estimated by aggressive (informed) trades positively and significantly predicts returns on the following day for the 2-year, 5-year and 10-year Treasury notes.

Chordia et al. (2002) and Chordia and Subrahmanyam (2004) find a positive relation between lagged daily imbalance and returns in stock market, but the sign reverses after controlling for the current imbalance due to inventory effects. However, this thesis show that on the macroeconomic announcement days with high dispersion of beliefs, daily trade imbalance estimated by informed trades still positively and significantly predicts returns, even after controlling for current trade imbalance. This result implies that aggressive trades and dispersion of beliefs among investors are associated with informed trading, which strengthen the return predictability of the trade imbalance. During the announcement days with high dispersion of beliefs, the announcements are not easy to interpret by all the investors. On those days, the traders with advanced trading skills can extract private information from the announcements and speculate in the Treasury market. Thus, during the period with high dispersion of beliefs, trade imbalance estimated by informed trades is more informative on the future returns. Moreover, findings in this thesis suggest that with short-lived information, informed traders are more likely to place aggressive orders.

Finally, based on the regression results, this thesis develops a trade-imbalance based trading strategy conditional on dispersion of beliefs and announcement days, which yields positive returns for 2-year, 5-year and 10-year Treasury notes. The returns are significantly positive for the 2-year notes when the announcement day order book slope is 25% or 30% lower than the average slope of the previous 365 days. The returns are positive for the 5-year and 10-year notes when the daily order book slope is 10%, 15%, 20%, 25% and 30% lower than the average slope of the previous 365 days, they are not significant though.

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Table 1
Daily Trading Volumes of U.S. Treasury Securities

The table reports descriptive statistics on daily trading volume for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with morning or afternoon announcements. Non-announcement days are those with no morning or afternoon announcements. There are 400 announcement days and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	412	327	406	297	0.8243	0.2235
Five-year note	299	267	285	237	0.3208	0.0913
Ten-year note	377	337	371	328	0.7224	0.3391
Thirty-year bond	25	19	24	19	0.5842	0.2601
Panel B: London						
Two-year note	1701	1514	1537	1346	0.0305*	0.0107*
Five-year note	958	852	888	819	0.0499*	0.0463*
Ten-year note	1000	900	933	854	0.0791	0.0398*
Thirty-year bond	119	104	112	97	0.2188	0.1874
Panel C: US						
Two-year note	26485	24929	22079	20124	<.0001**	<.0001**
Five-year note	23669	22528	19985	18741	<.0001**	<.0001**
Ten-year note	19479	19189	16399	15717	<.0001**	<.0001**
Thirty-year bond	2923	2825	2517	2384	<.0001**	<.0001**

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 2
Daily Trading Volumes of U.S. Treasury Securities (Days with top 30% surprise)

The table reports descriptive statistics on daily trading volume for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with 8:30 am announcement and with the top 30% surprise. Non-announcement days are those with no morning or afternoon announcements. There are 100 8:30am announcement days with top 30% surprise and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	378	305	406	297	0.4426	0.8637
Five-year note	297	250	285	237	0.5634	0.3345
Ten-year note	386	337	371	328	0.6032	0.5797
Thirty-year bond	25	18	24	19	0.8284	0.7290
Panel B: London						
Two-year note	1639	1467	1537	1346	0.4183	0.3924
Five-year note	907	770	888	819	0.7637	0.9115
Ten-year note	962	823	933	854	0.7251	0.7904
Thirty-year bond	123	94	112	97	0.3483	0.7828
Panel C: US						
Two-year note	27697	26915	22079	20124	<.0001**	<.0001**
Five-year note	25084	24046	19985	18741	<.0001**	<.0001**
Ten-year note	20943	20404	16399	15717	<.0001**	<.0001**
Thirty-year bond	3168	3096	2517	2384	<.0001**	<.0001**

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 3
Daily Trading Volumes of U.S. Treasury Securities (Days with bottom 25% slope)

The table reports descriptive statistics on daily trading volume for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with morning or afternoon announcements and with bottom 25% order book slope. Non-announcement days are those with no morning or afternoon announcements. There are 100 announcement days with bottom 25% order book slope and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	580	485	406	297	0.0005**	<.0001**
Five-year note	401	373	285	237	<.0001**	<.0001**
Ten-year note	368	337	371	328	0.8938	0.7578
Thirty-year bond	25	19	24	19	0.6751	0.4070
Panel B: London						
Two-year note	1970	1714	1537	1346	0.0002**	<.0001**
Five-year note	1118	1095	888	819	<.0001**	<.0001**
Ten-year note	1002	919	933	854	0.2277	0.1518
Thirty-year bond	114	91	112	97	0.8473	0.9316
Panel C: US						
Two-year note	32336	31963	22079	20124	<.0001**	<.0001**
Five-year note	27295	27075	19985	18741	<.0001**	<.0001**
Ten-year note	19985	20124	16399	15717	<.0001**	<.0001**
Thirty-year bond	2591	2391	2517	2384	0.5162	0.5168

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 4
Daily Trading Frequency of U.S. Treasury Securities

The table reports descriptive statistics on the daily number of trades for the indicated on-the-run securities for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with morning or afternoon announcements. Non-announcement days are those with no morning or afternoon announcements. There are 400 announcement days and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	39.7	28	38.5	28	0.6484	0.2338
Five-year note	61.8	50	56.6	47	0.0818	0.0422*
Ten-year note	83.9	75	80.2	74	0.3008	0.1442
Thirty-year bond	13.6	12	13	10	0.4540	0.1474
Panel B: London						
Two-year note	116.2	88	107.7	80	0.1504	0.0544
Five-year note	158.5	130	146.5	124	0.0546	0.0451*
Ten-year note	179.9	156.5	169.9	154	0.1218	0.0879
Thirty-year bond	56.2	51	54.2	50	0.3875	0.3227
Panel C: US						
Two-year note	1026	757	879	628.5	0.0017**	<.0001**
Five-year note	1983.6	1651.5	1734.7	1425	0.0002**	<.0001**
Ten-year note	1843.2	1670.5	1614.8	1452	<.0001**	<.0001**
Thirty-year bond	981.1	954.5	856.4	820	<.0001**	<.0001**

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 5
Daily Trading Frequency of U.S. Treasury Securities (Days with top 30% surprise)

The table reports descriptive statistics on the daily number of trades for the indicated on-the-run securities for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with 8:30 am announcement and with the top 30% surprise. Non-announcement days are those with no morning or afternoon announcements. There are 100 8:30am announcement days with top 30% surprise and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	37.9	27	38.5	28	0.8641	0.4779
Five-year note	64	52	56.6	47	0.1153	0.0782
Ten-year note	87.7	78.5	80.2	74	0.1938	0.1160
Thirty-year bond	13.6	12	13	10	0.6162	0.3590
Panel B: London						
Two-year note	108.5	87.5	107.7	80	0.9273	0.5553
Five-year note	150.1	121	146.5	124	0.7214	0.9548
Ten-year note	175	145	169.9	154	0.6478	0.9909
Thirty-year bond	55.5	48	54.2	50	0.7545	0.9508
Panel C: US						
Two-year note	1087.3	816.5	879	628.5	0.0072**	<.0001**
Five-year note	2103.9	1696.5	1734.7	1425	0.0010**	<.0001**
Ten-year note	1964.1	1746.5	1614.8	1452	<.0001**	<.0001**
Thirty-year bond	1050.2	1032.5	856.4	820	<.0001**	<.0001**

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 6
Daily Trading Frequency of U.S. Treasury Securities (Days with bottom 25% slope)

The table reports descriptive statistics on the daily number of trades for the indicated on-the-run securities for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with morning or afternoon announcements and with bottom 25% order book slope. Non-announcement days are those with no morning or afternoon announcements. There are 100 announcement days with bottom 25% order book slope and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement day. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	70.8	64	38.5	28	<.0001**	<.0001**
Five-year note	97.7	92	56.6	47	<.0001**	<.0001**
Ten-year note	107.2	101.5	80.2	74	<.0001**	<.0001**
Thirty-year bond	15.1	13	13	10	0.0961	0.0496*
Panel B: London						
Two-year note	208	207	107.7	80	<.0001**	<.0001**
Five-year note	235.7	236.5	146.5	124	<.0001**	<.0001**
Ten-year note	236.5	235	169.9	154	<.0001**	<.0001**
Thirty-year bond	59.8	49	54.2	50	0.1540	0.1675
Panel C: US						
Two-year note	1857.3	1862	879	628.5	<.0001**	<.0001**
Five-year note	3070	3173	1734.7	1425	<.0001**	<.0001**
Ten-year note	2554.9	2586.5	1614.8	1452	<.0001**	<.0001**
Thirty-year bond	1067.9	1032.5	856.4	820	<.0001**	<.0001**

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 7
Trade Sizes of U.S. Treasury Securities

The table reports descriptive statistics on mean daily trade sizes for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. There are 400 announcement days and 350 non-announcement days. Announcement days are defined as those with morning or afternoon announcements. Non-announcement days are those with no morning or afternoon announcements. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	11.1	10.5	11	10	0.8686	0.8904
Five-year note	5	4.8	5.1	4.9	0.4158	0.5538
Ten-year note	4.6	4.5	4.7	4.6	0.4046	0.4446
Thirty-year bond	1.8	1.7	1.9	1.7	0.2885	0.8046
Panel B: London						
Two-year note	16.5	15.3	15.8	14.5	0.1547	0.1538
Five-year note	6.3	6.1	6.3	6.1	0.9783	0.8889
Ten-year note	5.7	5.7	5.6	5.7	0.3427	0.5452
Thirty-year bond	2	2	2	2	0.4526	0.7143
Panel C: US						
Two-year note	29.4	29.6	28.8	28.8	0.3863	0.2864
Five-year note	12.8	12.7	12.3	12.2	0.0225*	0.0217*
Ten-year note	11.2	11.7	10.7	10.9	0.0053**	0.0004**
Thirty-year bond	3	3	2.9	2.9	0.2834	0.2143

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 8
Trade Sizes of U.S. Treasury Securities (Days with top 30% surprise)

The table reports descriptive statistics on mean daily trade sizes for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with 8:30 am announcement and with the top 30% surprise. Non-announcement days are those with no morning or afternoon announcements. There are 100 8:30am announcement days with top 30% surprise and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcements. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	10.5	9.8	11.0	10.0	0.2991	0.3945
Five-year note	4.7	4.6	5.1	4.9	0.0449*	0.0568
Ten-year note	4.4	4.3	4.7	4.6	0.0570	0.0327*
Thirty-year bond	1.8	1.6	1.9	1.7	0.1269	0.4693
Panel B: London						
Two-year note	16.7	14.5	15.8	14.5	0.2905	0.4695
Five-year note	6.2	6.1	6.3	6.1	0.5675	0.6396
Ten-year note	5.6	5.6	5.6	5.7	0.7819	0.5214
Thirty-year bond	2.1	2.0	2.0	2.0	0.4473	0.6277
Panel C: US						
Two-year note	28.8	28.9	28.8	28.8	0.9702	0.9004
Five-year note	12.8	12.8	12.3	12.2	0.2180	0.1815
Ten-year note	11.3	11.6	10.7	10.9	0.0584	0.0173*
Thirty-year bond	3.0	3.0	2.9	2.9	0.4409	0.3545

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 9
Trade Sizes of U.S. Treasury Securities (Days with bottom 25% slope)

The table reports descriptive statistics on mean daily trade sizes for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with morning or afternoon announcements and with bottom 25% order book slope. Non-announcement days are those with no morning or afternoon announcements. There are 100 announcement days with bottom 25% order book slope and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement day. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	7.9	7.5	11	10	<.0001**	<.0001**
Five-year note	4.2	3.8	5.1	4.9	<.0001**	<.0001**
Ten-year note	3.4	3.3	4.7	4.6	<.0001**	<.0001**
Thirty-year bond	1.6	1.5	1.9	1.7	0.0020**	0.0235*
Panel B: London						
Two-year note	9.6	9	15.8	14.5	<.0001**	<.0001**
Five-year note	4.8	4.5	6.3	6.1	<.0001**	<.0001**
Ten-year note	4.3	3.9	5.6	5.7	<.0001**	<.0001**
Thirty-year bond	1.8	1.7	2	2	<.0001**	<.0001**
Panel C: US						
Two-year note	18.3	17.1	28.8	28.8	<.0001**	<.0001**
Five-year note	9.3	8.8	12.3	12.2	<.0001**	<.0001**
Ten-year note	8.3	7.5	10.7	10.9	<.0001**	<.0001**
Thirty-year bond	2.4	2.3	2.9	2.9	<.0001**	<.0001**

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 10
Quote Sizes of U.S. Treasury Securities

The table reports descriptive statistics on mean daily quotes sizes for the indicated on-the -run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Quotes sizes are the quantity of securities bid for or offered for sale at the best bid and offer prices in the electronic market, the mean daily figure is calculated with both bid and offer quantities. Announcement days are defined as those with morning or afternoon announcements. Non-announcement days are those with no morning or afternoon announcements. There are 400 announcement days and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	46.2	32.9	45.7	34.9	0.8267	0.7083
Five-year note	13	11.8	12.9	11.8	0.8476	0.9844
Ten-year note	13.9	13.1	14.1	13.1	0.7914	0.9001
Thirty-year bond	2.6	2.4	2.5	2.4	0.1121	0.2932
Panel B: London						
Two-year note	105.6	82.9	105.2	80.1	0.9481	0.7933
Five-year note	23.2	19.9	23.3	20.3	0.9223	0.8865
Ten-year note	22.3	21.3	22.2	21.2	0.8871	0.9009
Thirty-year bond	3.5	3.2	3.6	3.3	0.7444	0.5666
Panel C: US						
Two-year note	267.3	260.6	279.4	264.7	0.2766	0.2966
Five-year note	54	53.4	56.4	56.7	0.1524	0.1357
Ten-year note	52.7	54	54.5	55	0.2234	0.2429
Thirty-year bond	6	5.5	6.1	5.6	0.6997	0.4976

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 11
Quote Sizes of U.S. Treasury Securities (Days with top 30% surprise)

The table reports descriptive statistics on mean daily electronic trading quotes sizes for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Quotes sizes are the quantity of securities bid for or offered for sale at the best bid and offer prices in the electronic market; the mean daily figure is calculated with both bid and offer quantities. Announcement days are defined as those with 8:30 am announcement and with top 30% macroeconomic surprise. Non-announcement days are those with no morning or afternoon announcements. There are 100 8:30am announcement days with top 30% surprise and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	41.4	29.9	45.7	34.9	0.1973	0.2751
Five-year note	12.4	11.2	12.9	11.8	0.5151	0.3902
Ten-year note	13.3	12.6	14.1	13.1	0.3508	0.3518
Thirty-year bond	2.6	2.2	2.5	2.4	0.7372	0.2697
Panel B: London						
Two-year note	101.1	77.8	105.2	80.1	0.6438	0.6983
Five-year note	21.4	18.2	23.3	20.3	0.1880	0.2094
Ten-year note	21.3	19.3	22.2	21.2	0.4897	0.5831
Thirty-year bond	3.4	3	3.6	3.3	0.4851	0.2267
Panel C: US						
Two-year note	257.3	255.6	279.5	264.7	0.1796	0.2331
Five-year note	52.1	52.8	56.4	56.7	0.0800	0.1152
Ten-year note	50.4	53.2	54.5	55	0.0595	0.1208
Thirty-year bond	5.8	5.4	6.1	5.6	0.3370	0.3840

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 12
Quote Sizes of U.S. Treasury Securities (Days with bottom 25% slope)

The table reports descriptive statistics on mean daily electronic trading quotes sizes for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Quotes sizes are the quantity of securities bid for or offered for sale at the best bid and offer prices in the electronic market; the mean daily figure is calculated with both bid and offer quantities. Announcement days are defined as those with morning or afternoon announcements and with bottom 25% order book slope. Non-announcement days are those with no morning or afternoon announcements. There are 100 announcement days with bottom 25% order book slope and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	20	18.1	45.7	34.9	<.0001**	<.0001**
Five-year note	7.2	6.7	12.9	11.8	<.0001**	<.0001**
Ten-year note	7.4	6	14.1	13.1	<.0001**	<.0001**
Thirty-year bond	2.1	1.9	2.5	2.4	<.0001**	<.0001**
Panel B: London						
Two-year note	34.2	33.6	105.2	80.1	<.0001**	<.0001**
Five-year note	10.8	8.3	23.3	20.3	<.0001**	<.0001**
Ten-year note	10.5	8.5	22.2	21.2	<.0001**	<.0001**
Thirty-year bond	2.4	2	3.6	3.3	<.0001**	<.0001**
Panel C: US						
Two-year note	85.7	75.7	279.5	264.7	<.0001**	<.0001**
Five-year note	28.3	24.5	56.4	56.7	<.0001**	<.0001**
Ten-year note	30.1	27.1	54.5	55	<.0001**	<.0001**
Thirty-year bond	3.8	3.3	6.1	5.6	<.0001**	<.0001**

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 13
Daily Absolute Net Numbers of Trades of U.S. Treasury Securities

The table reports descriptive statistics on daily absolute net number of trades for the indicated on-the-run securities for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. The daily absolute net number of trades equals the absolute value of daily net number of trade (the buyer initiated trades minus the seller initiated trades). Announcement days are defined as those with morning or afternoon announcements. Non-announcement days are those with no morning or afternoon announcements. There are 400 announcement days and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement day. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test	Median Test
Issue	Mean	Median	Mean	Median	P Value	P Value
Panel A: Tokyo						
Two-year note	7.1	5	7.6	5	0.4400	0.4387
Five-year note	10.1	8	9.2	7	0.1772	0.0476*
Ten-year note	10.5	8	10.7	9	0.8595	0.3819
Thirty-year bond	3.8	3	4.1	3	0.2971	0.5562
Panel B: London						
Two-year note	10.4	8	11.1	8	0.3830	0.9241
Five-year note	14	11	13.6	11	0.5791	0.5387
Ten-year note	14.6	13	14.6	11	0.9805	0.4908
Thirty-year bond	7.3	5	7	5	0.4358	0.3059
Panel C: US						
Two-year note	45.9	37	43.6	34	0.4128	0.3986
Five-year note	88.9	76.5	80.5	65.5	0.0852	0.1406
Ten-year note	61.5	52	57.5	47.5	0.2424	0.1741
Thirty-year bond	34.3	27	35.2	27.5	0.6580	0.7467

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 14
Daily Absolute Net Numbers of Trades of U.S. Treasury Securities
(Days with top 30% surprise)

The table reports descriptive statistics on daily absolute net number of trades for the indicated on-the-run securities for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. The daily absolute net number of trades equals the absolute value of daily net number of trade (the buyer initiated trades minus the seller initiated trades). Announcement days are defined as those with 8:30 am announcement and with top 30% macroeconomic surprise. Non-announcement days are those with no morning or afternoon announcements. There are 100 8:30am announcement days with top 30% surprise and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test	Median Test
Issue	Mean	Median	Mean	Median	P Value	P Value
Panel A: Tokyo						
Two-year note	6.4	5.0	7.6	5.0	0.1115	0.4387
Five-year note	9.5	7.0	9.2	7.0	0.7423	0.0476*
Ten-year note	11.1	7.0	10.7	9.0	0.7468	0.3819
Thirty-year bond	3.5	2.0	4.1	3.0	0.1403	0.5562
Panel B: London						
Two-year note	9.8	7.0	11.1	8.0	0.2915	0.9241
Five-year note	12.5	9.5	13.6	11.0	0.4019	0.5387
Ten-year note	14.1	13.0	14.6	11.0	0.6471	0.4908
Thirty-year bond	8.0	6.0	7.0	5.0	0.2643	0.3059
Panel C: US						
Two-year note	41.9	32.0	43.6	34.0	0.6458	0.3986
Five-year note	92.0	83.5	80.5	65.5	0.1158	0.1406
Ten-year note	57.6	45.5	57.5	47.5	0.9787	0.1741
Thirty-year bond	34.1	25.5	35.2	27.5	0.7206	0.7467

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 15
Daily Absolute Net Numbers of Trades of U.S. Treasury Securities
(Days with bottom 25% slope)

The table reports descriptive statistics on daily absolute net number of trades for the indicated on-the-run securities for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. The daily absolute net number of trades equals the absolute value of daily net number of trade (the buyer initiated trades minus the seller initiated trades). Announcement days are defined as those with morning or afternoon announcements and with bottom 25% order book slope. Non-announcement days are those with no morning or afternoon announcements. There are 100 announcement days with bottom 25% order book slope and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	9.5	7	7.6	5	0.0445*	0.0666
Five-year note	14.5	12	9.2	7	<.0001**	<.0001**
Ten-year note	13	10	10.7	9	0.0618	0.1213
Thirty-year bond	4.1	3	4.1	3	0.8831	0.9345
Panel B: London						
Two-year note	14.2	10	11.1	8	0.0211*	0.0084**
Five-year note	15.4	13	13.6	11	0.1863	0.1569
Ten-year note	14.5	13	14.6	11	0.9420	0.6625
Thirty-year bond	8.4	7	7	5	0.0748	0.0254*
Panel C: US						
Two-year note	57.1	46.5	43.6	34	0.0046**	0.0028**
Five-year note	103.4	87.5	80.5	65.5	0.0104*	0.0057**
Ten-year note	64.4	50	57.5	47.5	0.2610	0.4695
Thirty-year bond	37.1	32	35.2	27.5	0.5814	0.4010

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 16
Bid-Ask Spreads of U.S. Treasury Securities

The table reports descriptive statistics on mean daily bid-ask spread for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with morning or afternoon announcements. Non-announcement days are those with no morning or afternoon announcements. There are 400 announcement days and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	0.01329	0.01263	0.01489	0.01254	0.0895	0.4976
Five-year note	0.01724	0.01588	0.01954	0.01603	0.0855	0.5738
Ten-year note	0.02696	0.02506	0.03021	0.02521	0.0846	0.4340
Thirty-year bond	0.11182	0.08079	0.11953	0.08425	0.2283	0.2456
Panel B: London						
Two-year note	0.00962	0.00939	0.0099	0.00939	0.1321	0.6276
Five-year note	0.01186	0.01092	0.01238	0.01102	0.1209	0.4845
Ten-year note	0.02179	0.02072	0.02268	0.02068	0.1526	0.9788
Thirty-year bond	0.05863	0.03937	0.06318	0.03846	0.3749	0.8932
Panel C: US						
Two-year note	0.00829	0.00819	0.00826	0.00816	0.2150	0.0704
Five-year note	0.00921	0.00893	0.00915	0.0089	0.2671	0.2170
Ten-year note	0.01762	0.0173	0.01756	0.01726	0.4021	0.2367
Thirty-year bond	0.03131	0.02851	0.03057	0.02803	0.1996	0.0129*

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 17
Bid-Ask Spreads of U.S. Treasury Securities (Days with top 30% surprise)

The table reports descriptive statistics on mean daily bid-ask spread for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with 8:30 am announcement and with top 30% macroeconomic surprise. Non announcement days are those with no morning or afternoon announcements. There are 100 8:30am announcement days with top 30% surprise and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	0.01352	0.01276	0.01489	0.01254	0.2007	0.7428
Five-year note	0.01684	0.01587	0.01954	0.01603	0.0413*	0.5738
Ten-year note	0.02698	0.02565	0.03021	0.02521	0.0917	0.6109
Thirty-year bond	0.11653	0.08115	0.11953	0.08425	0.7677	0.5169
Panel B: London						
Two-year note	0.00967	0.00953	0.0099	0.00939	0.2640	0.8176
Five-year note	0.01202	0.01111	0.01238	0.01102	0.3928	0.4845
Ten-year note	0.02195	0.02086	0.02268	0.02068	0.3036	0.6810
Thirty-year bond	0.06352	0.04001	0.06318	0.03846	0.9631	0.7759
Panel C: US						
Two-year note	0.00831	0.00820	0.00826	0.00816	0.1917	0.0723
Five-year note	0.00925	0.00899	0.00915	0.00890	0.2162	0.2170
Ten-year note	0.01766	0.01734	0.01756	0.01726	0.3871	0.3561
Thirty-year bond	0.03179	0.02902	0.03057	0.02803	0.1822	0.0236*

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 18
Bid-Ask Spreads of U.S. Treasury Securities (Days with bottom 25% slope)

The table reports descriptive statistics on mean daily bid-ask spread for the indicated on-the-run securities in millions of U.S. dollars for Tokyo, London and U.S. trading hours, for both announcement days and non-announcement days. Announcement days are defined as those with morning or afternoon announcements and with bottom 25% order book slope. Non-announcement days are those with no morning or afternoon announcements. There are 100 8:30am announcement days with bottom 25% order book slope and 350 non-announcement days. We report the p-values from the t-statistic and wilcoxon signed rank statistic to compare means and medians for announcement and non-announcement days. The sample period is June 1, 2005 to May 30, 2008.

	Announcement days		**Non-announcement days**		Mean Test P Value	Median Test P Value
Issue	Mean	Median	Mean	Median		
Panel A: Tokyo						
Two-year note	0.0159	0.01447	0.01489	0.01254	0.3425	<.0001**
Five-year note	0.02149	0.01869	0.01954	0.01603	0.2924	<.0001**
Ten-year note	0.03391	0.03077	0.03021	0.02521	0.1144	<.0001**
Thirty-year bond	0.18605	0.15677	0.11953	0.08425	<.0001**	<.0001**
Panel B: London						
Two-year note	0.01073	0.01037	0.0099	0.00939	0.0002**	<.0001**
Five-year note	0.01483	0.01371	0.01238	0.01102	<.0001**	<.0001**
Ten-year note	0.02575	0.02465	0.02268	0.02068	0.0001**	<.0001**
Thirty-year bond	0.10439	0.06632	0.06318	0.03846	<.0001**	<.0001**
Panel C: US						
Two-year note	0.00868	0.00865	0.00826	0.00816	<.0001**	<.0001**
Five-year note	0.01012	0.01011	0.00915	0.00890	<.0001**	<.0001**
Ten-year note	0.01873	0.0187	0.01756	0.01726	<.0001**	<.0001**
Thirty-year bond	0.04011	0.0390	0.03057	0.02803	<.0001**	<.0001**

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.

Table 19
Bid-Ask Spread by One-Minute Interval

The reported bid-ask spread is the actual mean proportional spread times10^4. Announcement days are defined as those with 8:30 am announcement. Non announcement days are those with no morning or afternoon announcements. We report the p-values from the t-statistic to compare means for announcement and non-announcement days assuming unequal variance. All one-minute intervals between 8:25 am and 8:40 am are examined. The period of analysis is June 1, 2005 to May 30, 2008.

	8:25-8:26	8:26-8:27	8:27-8:28	8:28-8:29	8:29-8:30	8:30-8:31	8:31-8:32	8:32-8:33	8:33-8:34	8:34-8:35	8:35-8:36	8:36-8:37
					Panel A: Two-year notes							
Ann days	0.8486	0.8638	0.8762	0.9026	1.6277	1.1861	0.8500	0.8384	0.8204	0.8321	0.8258	0.8267
Non-Ann days	0.8347	0.8275	0.8216	0.8364	0.8654	0.8479	0.8256	0.8243	0.8162	0.8185	0.8088	0.8177
Difference in Means	0.0139	0.0363**	0.0547**	0.0661**	0.7623**	0.3382**	0.0244**	0.0141*	0.0042	0.0135	0.0170**	0.0090
t-statistic p-value	0.1536	0.0002	<.0001	<.0001	<.0001	<.0001	0.0014	0.0377	0.4533	0.0534	0.0032	0.1751
					Panel B: Five-year notes							
Ann days	0.9409	0.9723	0.9893	1.1222	2.7939	1.7880	0.9333	0.9217	0.9114	0.9057	0.9068	0.8870
Non-Ann days	0.9402	0.9434	0.9308	0.9364	1.0003	0.9643	0.9293	0.9207	0.9017	0.9155	0.8967	0.9045
Difference in Means	0.0007	0.0289*	0.0585**	0.1858**	1.7935**	0.8237**	0.0039	0.0010	0.0097	-0.0098	0.0101	-0.0174
t-statistic p-value	0.9630	0.0459	0.0006	<.0001	<.0001	<.0001	0.7542	0.9308	0.3442	0.3481	0.3386	0.0843
					Panel C: Ten-year notes							
Ann days	1.7800	1.8109	1.8520	1.9674	3.9203	2.8242	1.7690	1.7689	1.7562	1.7296	1.7549	1.7278
Non-Ann days	1.7725	1.7914	1.7960	1.8146	1.8954	1.8413	1.7800	1.7799	1.7602	1.8092	1.7652	1.7689
Difference in Means	0.0074	0.0195	0.0560*	0.1528**	2.0249**	0.9828**	-0.0111	-0.0110	-0.0039	-0.0796**	-0.0103	-0.0411*
t-statistic p-value	0.7342	0.4151	0.0286	<.0001	<.0001	<.0001	0.5634	0.5868	0.8418	<.0001	0.5944	0.0346
					Panel D: Thirty-year bond							
Ann days	3.3287	3.3977	4.0617	5.3129	12.0114	10.0303	3.9652	3.1537	3.0496	3.0146	2.9894	2.9420
Non-Ann days	2.8885	2.9684	3.0379	3.0532	3.6762	3.3704	2.9695	2.8610	2.8603	2.8949	2.9330	2.8867
Difference in Means	0.4402**	0.4293**	1.0239**	2.2597**	8.3352**	6.6599**	0.9957**	0.2927**	0.1893**	0.1198	0.0564	0.0553
t-statistic p-value	0.0012	<.0001	0.0022	<.0001	<.0001	<.0001	0.0046	0.0004	0.0082	0.0737	0.4530	0.4069

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.
Ann days and Non-Ann days represent announcement days and Non-announcement days, respectively.

Table 20
Bid-Ask Spread by One-Minute Interval (Days with top 30% surprise)

The reported bid-ask spread is the actual mean proportional spread times10^4. Announcement days are defined as those with 8:30 am announcement and with top 30% macroeconomic surprise. Non announcement days are those with no morning or afternoon announcements. We report the p-values from the t-statistic to compare means for announcement and non-announcement days assuming unequal variance. All one-minute intervals between 8:25 am and 8:40 am are examined. The period of analysis is June 1, 2005 to May 30, 2008.

	8:25-8:26	8:26-8:27	8:27-8:28	8:28-8:29	8:29-8:30	8:30-8:31	8:31-8:32	8:32-8:33	8:33-8:34	8:34-8:35	8:35-8:36	8:36-8:37
Panel A: Two-year notes												
Ann days	0.8594	0.8530	0.8811	0.9252	2.0658	1.2858	0.8502	0.8392	0.8348	0.8395	0.8342	0.8287
Non-Ann days	0.8347	0.8275	0.8216	0.8364	0.8654	0.8479	0.8256	0.8243	0.8162	0.8185	0.8088	0.8177
Difference in Means	0.0247	0.0256	0.0595**	0.0888**	1.2004**	0.4380**	0.0246*	0.0150	0.0186*	0.0209	0.0255**	0.0110
t-statistic p-value	0.1178	0.0586	0.0012	0.0043	0.0006	<.0001	0.0150	0.0934	0.0264	0.0540	0.0050	0.2254
Panel B: Five-year notes												
Ann days	0.9292	0.9557	1.0247	1.2086	3.5697	2.1728	0.9393	0.9245	0.9065	0.8997	0.9051	0.8941
Non-Ann days	0.9402	0.9434	0.9308	0.9364	1.0003	0.9643	0.9293	0.9207	0.9017	0.9155	0.8967	0.9045
Difference in Means	-0.0110	0.0123	0.0940**	0.2722**	2.5693**	1.2085**	0.0100	0.0038	0.0047	-0.0158	0.0084	-0.0104
t-statistic p-value	0.5780	0.4963	0.0047	0.0055	<.0001	<.0001	0.6192	0.7969	0.7304	0.2571	0.5549	0.4595
Panel C: Ten-year notes												
Ann days	1.7654	1.7771	1.8015	2.0683	4.9879	3.2995	1.7685	1.7732	1.7537	1.7306	1.7386	1.7194
Non-Ann days	1.7725	1.7914	1.7960	1.8146	1.8954	1.8413	1.7800	1.7799	1.7602	1.8092	1.7652	1.7689
Difference in Means	-0.0071	-0.0144	0.0055	0.2537**	3.0925**	1.4582**	-0.0115	-0.0067	-0.0065	-0.0786**	-0.0267	-0.0495*
t-statistic p-value	0.8067	0.6528	0.8776	0.0033	<.0001	<.0001	0.6335	0.8016	0.8141	0.0022	0.2744	0.0349
Panel D: Thirty-year bond												
Ann days	3.6304	3.6005	4.7261	6.4468	14.1353	13.1883	4.8666	3.2599	3.0728	3.0220	3.0556	2.9757
Non-Ann days	2.8885	2.9684	3.0379	3.0532	3.6762	3.3704	2.9695	2.8610	2.8603	2.8949	2.9330	2.8867
Difference in Means	0.7419*	0.6321**	1.6883	3.3936**	10.4592**	9.8179**	1.8971*	0.3990*	0.2125	0.1271	0.1226	0.0890
t-statistic p-value	0.0196	<.0001	0.0577	0.0040	<.0001	<.0001	0.0434	0.0136	0.0611	0.2055	0.3484	0.3392

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.
Ann days and Non-Ann days represent announcement days and Non-announcement days, respectively.

Table 21
Bid-Ask Spread by One-Minute Interval (Days with bottom 25% slope)

The reported bid-ask spread is the actual mean proportional spread times10^4. Announcement days are defined as those with 8:30 am announcement and with the bottom 25% order book slope. Non announcement days are those with no morning or afternoon announcements. We report the p-values from the t-statistic to compare means for announcement and non announcement days assuming unequal variance. All one-minute intervals between 8:25 am and 8:40 am are examined. The period of analysis is June 1, 2005 to May 30, 2008.

	8:25-8:26	8:26-8:27	8:27-8:28	8:28-8:29	8:29-8:30	8:30-8:31	8:31-8:32	8:32-8:33	8:33-8:34	8:34-8:34	8:35-8:36	8:36-8:37
					Panel A: Two-year notes							
Ann days	0.8927	0.9353	0.9331	0.9943	1.8511	1.2280	0.9007	0.8897	0.8577	0.8828	0.8637	0.8684
Non-Ann days	0.8347	0.8275	0.8216	0.8364	0.8654	0.8479	0.8256	0.8243	0.8162	0.8185	0.8088	0.8177
Difference in Means	0.0580**	0.1078**	0.1115**	0.1579**	0.9857**	0.3801**	0.0751**	0.0654**	0.0415**	0.0643**	0.0549**	0.0507**
t-statistic p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
					Panel B: Five-year notes							
Ann days	1.0400	1.1182	1.1132	1.2662	3.8294	2.0949	1.0168	1.0058	1.0070	1.0095	0.9942	0.9740
Non-Ann days	0.9402	0.9434	0.9308	0.9364	1.0003	0.9643	0.9293	0.9207	0.9017	0.9155	0.8967	0.9045
Difference in Means	0.0998**	0.1748**	0.1824**	0.3298**	2.8291**	1.1306**	0.0875**	0.0851**	0.1053**	0.0940**	0.0975**	0.0695**
t-statistic p-value	<.0001	<.0001	<.0001	0.0007	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
					Panel C: Ten-year notes							
Ann days	1.9038	1.8864	1.9335	2.0949	4.7801	3.1256	1.8704	1.8357	1.8907	1.8375	1.8735	1.8228
Non-Ann days	1.7725	1.7914	1.7960	1.8146	1.8954	1.8413	1.7800	1.7799	1.7602	1.8092	1.7652	1.7689
Difference in Means	0.1313**	0.0950**	0.1375**	0.2803**	2.8847**	1.2843**	0.0904**	0.0558*	0.1305**	0.0283	0.1083**	0.0539*
t-statistic p-value	<.0001	0.0022	<.0001	0.0002	<.0001	<.0001	0.0009	0.0317	<.0001	0.3201	0.0005	0.0492
					Panel D: Thirty-year bond							
Ann days	4.4209	4.1999	5.5826	7.1659	15.8808	9.4602	4.1933	4.1277	3.8969	3.7669	3.8552	3.7634
Non-Ann days	2.8885	2.9684	3.0379	3.0532	3.6762	3.3704	2.9695	2.8610	2.8603	2.8949	2.9330	2.8867
Difference in Means	1.5324**	1.2315**	2.5447**	4.1127**	12.2046**	6.0898**	1.2238**	1.2667**	1.0366**	0.8720**	0.9222**	0.8767**
t-statistic p-value	<.0001	<.0001	0.005	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

* and ** indicate significant at the 0.05 and 0.01 levels, respectively.
Ann days and Non-Ann days represent announcement days and Non-announcement days, respectively.

Table 22
Order Book Slope Statistics (1)

This table presents summary statistics for the order book slope for 2-year, 5-year, 10-year notes and 30-year bonds for each half-hour trading frequency. The sample period is from June 1, 2005 to May 30, 2008 during the U.S. trading hours. Slope is the limit order book slope based on 5 tiers quotes. Relative Slope is measured by the relative slope of demand side over supply side. The statistics is the actual statistic multiplied by 10^{-3}. Ann period is the period with macroeconomic announcements, while Non-Ann is the period without macroeconomic announcements.

Panel A: Two-year note			
	All sample	Non-Ann period	Ann period
ask slope	25.04	24.97	27.07
bid slope	25.23	25.16	26.91
order book slope	25.14	25.07	26.99
relative slope	0.50	0.50	0.50
Panel B: Five-year note			
	All sample	Non-Ann period	Ann period
ask slope	17.60	17.56	18.72
bid slope	17.68	17.64	18.65
order book slope	17.64	17.60	18.69
relative slope	0.50	0.50	0.50
Panel C: Ten-year note			
	All sample	Non-Ann period	Ann period
ask slope	9.03	9.02	9.40
bid slope	9.09	9.07	9.60
order book slope	9.06	9.05	9.50
relative slope	0.50	0.50	0.51
Panel D: Thirty-year bond			
	All sample	Non-Ann period	Ann period
ask slope	3.88	3.87	4.09
bid slope	3.89	3.88	4.04
order book slope	3.89	3.88	4.06
relative slope	0.50	0.50	0.50

Table 23
Order Book Slope Statistics (2)

This table presents summary statistics for the order book slope for 2-year, 5-year, 10-year notes and 30-year bonds for each half-hour trading frequency. The sample period is from May 31, 2007 to May 30, 2008 during the U.S. trading hours. Slope is the limit order book slope based on 5 tiers quotes. Relative Slope is measured by the relative slope of demand side over supply side. The statistics is the actual statistic multiplied by 10^{-3}. Low range Ann-periods are the periods of announcements in the bottom 20% forecast range. High range Ann-periods are the periods of announcements with top 20% forecast range.

Panel A: Two-year note		
	low range Ann-period	high range Ann-period
ask slope	23.32	22.75
bid slope	22.49	21.62
order book slope	22.90	22.19
relative slope	0.49	0.49
Panel B: Five-year note		
	low range Ann-period	high range Ann-period
ask slope	16.49	15.49
bid slope	16.42	15.51
order book slope	16.46	15.50
relative slope	0.50	0.50
Panel C: Ten-year note		
	low range Ann-period	high range Ann-period
ask slope	8.08	7.92
bid slope	8.37	8.34
order book slope	8.23	8.13
relative slope	0.51	0.51
Panel D: Thirty-year bond		
	low range Ann-period	high range Ann-period
ask slope	3.63	3.31
bid slope	3.41	3.14
order book slope	3.52	3.23
relative slope	0.49	0.49

Table 24
Price Impact by Different Definitions of Trade Imbalance

The results are for 2-year, 5-year, 10-year notes and 30-year bonds for the period from June 1, 2005 to May 30, 2008 during the U.S. trading hours. The model examines the relationship between trade imbalance (TIB) and price changes. TIB is defined in two different ways (TIBNUM and RELTIBNUM). TIBNUM is the number of buyer-initiated trades minus the number of seller-initiated trades. RELTIBNUM is the number of buyer-initiated trades minus the number of seller-initiated trades, divides by the total number of trades. The model is defined as follows:

$$\Delta P_t = incercept + \phi TIB_t + \varepsilon_t$$

	2-year notes	5-year notes	10-year notes	30-year bonds
Panel A: TIB is defined as TIBNUM				
intercept	0.000147(.000)	0.000786(.000)	0.000560(.000)	0.0006376(.005)
ϕ	0.000973(.000)	0.001530(.000)	0.002560(.000)	0.005760(.000)
$\bar{R}^2$	0.1159	0.1144	0.1293	0.0823
Panel B: TIB is defined as RELTIBNUM				
intercept	0.000041(.267)	0.000337(.000)	0.000259(.032)	0.000274(.230)
ϕ	0.003940(.000)	0.012050(.000)	0.019630(.000)	0.030150(.000)
$\bar{R}^2$	0.039	0.0429	0.0508	0.0491

Table 25
Daily Regression of Returns on Trade Imbalance, Order Book Imbalance and Lagged Trade Imbalance

The results are for 2-year, 5-year, 10-year notes and 30-year bonds for the period from June 1, 2005 to May 30, 2008 during the U.S. trading hours (7:30 am to 5:30pm ET). The regression examines the relationship between daily return and daily trade imbalance, limit order book imbalance and lagged daily Trade Imbalance. TIB is the number of buyer-initiated trades minus the number of seller-initiated trades. TIBA1 is the trade imbalance calculated by the A1 trades with medium and lager size. OIB the order book imbalance calculated by 5 tiers of order book. Ann is the dummy variable, which equals to 1 when there morning or afternoon announcement, and equals to 0 otherwise. AD is the dummy variable, which equals to 1 when the slope is in the bottom 1/4, 1/5 or 1/6 on announcement days, and equals to 0 otherwise.

$$R_t = \beta_0 + \beta_1 TIBA1_t + \beta_2\, OIB_t + \beta_3 * OIB_t * Ann_t + \beta_4 * TIBA1_t * AD_t + \beta_5 TIBA1_{t-1} + \beta_6 * TIBA1_{t-1} * AD_{t-1} + \varepsilon_t$$

	2-year notes	5-year notes	10-year notes	30-year bonds
Panel A: AD is the dummy for bottom 1/4 slope announcement days				
β_0	-0.00006318	-0.00002378	-0.00010013	-0.00009554
	(0.1049)	(0.8013)	(0.4591)	(0.6944)
β_1	0.00005448	0.00003546	0.00012578	0.00020618
	(<.0001)	(<.0001)	(<.0001)	(<.0001)
β_2	1.221498E-7	9.542393E-7	0.00000144	0.00001423
	(0.0040)	(0.0241)	(0.0111)	(0.0208)
β_3	8.85511E-8	2.498415E-7	9.835742E-7	-0.00001973
	(0.1235)	(0.6458)	(0.2366)	(0.0185)
β_4	0.00000704	-0.00002656	-0.00002718	-0.00022767
	(0.6863)	(0.0375)	(0.2218)	(0.0186)
β_5	-0.00003424	-0.00000551	-0.00001844	0.00005549
	(0.0024)	(0.4910)	(0.2070)	(0.1421)
β_6	0.00005328	0.00003877	0.00004353	-0.00011294
	(0.0023)	(0.0027)	(0.0502)	(0.2425)
$\bar{R}^2$	0.1036	0.0592	0.1459	0.0415

Panel B: AD is the dummy for bottom 1/5 slope announcement days

β_0	-0.00006394	-0.00002187	-0.00009914	0.00010129
	(0.1008)	(0.8168)	(0.4631)	(0.6780)
β_1	0.00005353	0.00003727	0.00012573	0.00018817
	(<.0001)	(<.0001)	(<.0001)	(<.0001)
β_2	1.22373E-7	9.509352E-7	0.00000141	0.00001425
	(0.0039)	(0.0243)	(0.0128)	(0.0211)
β_3	8.84727E-8	2.311531E-7	0.00000101	-0.00002011
	(0.1240)	(0.6700)	(0.2236)	(0.0166)
β_4	0.00000952	-0.00003286	-0.00003305	-0.00016099
	(0.5883)	(0.0104)	(0.1490)	(0.1731)
β_5	-0.00003266	-0.00000467	-0.00001777	0.00004200
	(0.0032)	(0.5497)	(0.1971)	(0.2531)
β_6	0.00005216	0.00004078	0.00005061	-0.00002083
	(0.0031)	(0.0016)	(0.0273)	(0.8602)
$\bar{R}^2$	0.1031	0.0635	0.1478	0.0352

Panel C: AD is the dummy for bottom 1/6 slope announcement days

β_0	-0.00006209	0.00002425	-0.00010230	-0.00010602
	(0.1076)	(0.7967)	(0.4498)	(0.6642)
β_1	0.00005160	0.00003572	0.00011977	0.00017871
	(<.0001)	(<.0001)	(<.0001)	(<.0001)
β_2	1.222841E-7	9.446675E-7	0.00000142	0.00001429
	(0.0036)	(0.0249)	(0.0120)	(0.0210)
β_3	8.915251E-8	2.391972E-7	0.00000100	-0.00002021
	(0.1177)	(0.6583)	(0.2271)	(0.0162)
β_4	0.00001134	-0.00003360	-0.00001792	-0.00007661
	(0.5364)	(0.0124)	(0.4448)	(0.5718)
β_5	-0.00003951	-0.00000595	-0.00001491	0.00003715
	(0.0001)	(0.4204)	(0.2681)	(0.3057)
β_6	0.00008697	0.00005239	0.00004796	0.00002289
	(<.0001)	(0.0001)	(0.0411)	(0.8661)
$\bar{R}^2$	0.1196	0.0686	0.1450	0.0333

Table 26
Predictability of Daily Returns by Using Lagged Trade Imbalance

The results are for 2-year, 5-year, 10-year notes and 30-year bonds for the period from June 1, 2005 to May 30, 2008 during the U.S. trading hours (7:30 am to 5:30pm ET). The regression examines the relationship between daily return and lagged daily Trade Imbalance. TIB is the number of buyer-initiated trades minus the number of seller-initiated trades. TIBA1 is the trade imbalance calculated by the A1 trades with medium and lager size. AD is the dummy variable, which equals to 1 when the slope is in the bottom 1/4, 1/5 or 1/6 on announcement days, and equals to 0 otherwise.

$$R_t = \beta_0 + \beta_1 TIB_{t-1} + \beta_2 TIBA1_{t-1} + \beta_3 TIB_{t-1} * AD_{t-1} + \beta_4 TIBA1_{t-1} * AD_{t-1} + \varepsilon_t$$

	2-year notes	5-year notes	10-year notes	30-year bonds
Panel A: AD is the dummy for bottom 1/4 slope announcement days				
β_0	-0.00001634	4.54E-07	-0.00007666	-0.00014965
	(0.6904)	(0.9967)	(0.6175)	(0.5675)
β_1	-0.00000169	6.81E-07	0.00000102	0.00000303
	(0.0287)	(0.5575)	(0.6524)	(0.6328)
β_2	-0.00002874	-0.00000846	-0.00002464	0.00004353
	(0.0156)	(0.3149)	(0.1295)	(0.2651)
β_3	0.00000213	-0.00000317	-0.00000631	0.00001711
	(0.2277)	(0.2022)	(0.2269)	(0.2753)
β_4	0.00004869	0.00005034	0.00004484	-0.00012005
	(0.0103)	(0.0005)	(0.0718)	(0.2245)
$\bar{R}^2$	0.0138	0.0141	0.0002	0.0003
Panel B: AD is the dummy for bottom 1/5 slope announcement days				
β_0	-0.00001655	-0.00000997	-0.00007595	-0.00015730
	(0.6866)	(0.9287)	(0.6201)	(0.5483)
β_1	-0.00000160	3.627848E-7	0.00000116	0.00000293
	(0.0346)	(0.7523)	(0.6039)	(0.6390)
β_2	-0.00002730	-0.00000740	-0.00002624	0.00002993
	(0.0194)	(0.3668)	(0.0863)	(0.4278)
β_3	0.00000214	-0.00000222	-0.00000806	0.00002379
	(0.2660)	(0.4170)	(0.1435)	(0.1637)
β_4	0.00004788	0.00005027	0.00005819	-0.00005911
	(0.0128)	(0.0008)	(0.0234)	(0.6242)
$\bar{R}^2$	0.0130	0.0139	0.0031	-0.0003
Panel C: AD is the dummy for bottom 1/6 slope announcement days				
β_0	-0.00001573	-0.00001488	-0.00008963	-0.00015644
	(0.6980)	(0.8932)	(0.5598)	(0.5508)
β_1	-0.00000175	3.312867E-7	-8.13108E-9	0.00000355
	(0.0184)	(0.7678)	(0.9971)	(0.5664)
β_2	-0.00003600	-0.00000691	-0.00002105	0.00002616
	(0.0010)	(0.3773)	(0.1591)	(0.4820)
β_3	0.00000317	-0.00000219	-6.92145E-7	0.00002278
	(0.1105)	(0.4740)	(0.9082)	(0.2190)
β_4	0.00008644	0.00005856	0.00004439	-0.00004119
	(<.0001)	(0.0002)	(0.0916)	(0.7671)
$\bar{R}^2$	0.0355	0.0181	-0.0009	-0.0010

Table 27
Profits from Trading Strategy Conditional on Dispersion of Beliefs

This table reports the average returns over the period from June 1, 2005 to May 30, 2008 for the 2-year, 5-year and 10-year notes. The returns are from a trading strategy that is based on low slope days (the days with an order book slope of 10%, 15%, 20%, 25% or 30% lower than the average of previous 365 days). TIB is trade imbalance estimated by all trades, while TIB_FA1 is trade imbalance estimated by the aggressive (informed) trades. On those days with high dispersion of beliefs, if the trade imbalance is positive, we buy at the opening ask quote and sell at the closing bid quote in the following day and vice versa. Return is calculated as the log changes of the first and last quotes of that day and it is reported in percentage points in the table. t- Statistic is in parentheses.

	2-year	5-year	10-year
Panel A: TIB			
slope 10% lower than average	**-0.036%**	**-0.002%**	**-0.034%**
	(-3.21)	(-0.09)	(-0.81)
slope 15% lower than average	**-0.035%**	**0.006%**	**-0.049%**
	(-2.78)	(0.19)	(-0.92)
slope 20% lower than average	**-0.027%**	**0.012%**	**-0.075%**
	(-1.68)	(0.29)	(-1.08)
slope 25% lower than average	**-0.015%**	**0.008%**	**-0.161%**
	(-0.65)	(0.15)	(-1.51)
slope 30% lower than average	**-0.010%**	**0.021%**	**-0.108%**
	(-0.3)	(0.27)	(-0.69)
Panel B: TIBA1			
slope 10% lower than average	**-0.016%**	**-0.004%**	**0.029%**
	(-1.4)	(-0.15)	(0.68)
slope 15% lower than average	**-0.002%**	**0.010%**	**0.043%**
	(-0.19)	(0.32)	(0.79)
slope 20% lower than average	**0.015%**	**0.001%**	**0.144%**
	(0.92)	(0.01)	(2.08)
slope 25% lower than average	**0.033%**	**-0.001%**	**0.062%**
	(1.49)	(-0.02)	(0.56)
slope 30% lower than average	**0.040%**	**0.033%**	**0.154%**
	(1.35)	(0.44)	(0.96)

Table 28
Profits from Trading Strategy Conditional on Dispersion of Beliefs and Announcement Days

This table reports the average returns over the period from June 1, 2005 to May 30, 2008 for the 2-year, 5-year and 10-year notes. The returns are resulting from the trading strategy that we buy or sell (i) if the previous day is an announcement day, and (ii) if the order book slope on the previous announcement day is lower (10%, 15%, 20% 25% or 30% lower) than the average slope of previous 365 announcement and non-announcement days. TIB is trade imbalance estimated by all trades, while TIB_FA1 is trade imbalance estimated by the aggressive (informed) trades. Return is calculated as the log changes of the first and last quotes of that day and it is reported in percentage points in the table. t- Statistic is in parentheses.

	2-year	5-year	10-year
Panel A: TIB			
slope 10% lower than average	**-0.033%**	**-0.001%**	**-0.033%**
	(-2.45)	(-0.03)	(-0.67)
slope 15% lower than average	**-0.030%**	**-0.004%**	**-0.004%**
	(-2.04)	(-0.09)	(-0.07)
slope 20% lower than average	**-0.015%**	**0.013%**	**0.003%**
	(-0.83)	(0.27)	(0.04)
slope 25% lower than average	**-0.005%**	**0.025%**	**-0.064%**
	(-0.19)	(0.40)	(-0.50)
slope 30% lower than average	**-0.002%**	**-0.025%**	**0.048%**
	(-0.06)	(-0.31)	(0.31)
Panel B: TIBA1			
slope 10% lower than average	**-0.017%**	**0.021%**	**0.028%**
	(-1.15)	(0.65)	(0.54)
slope 15% lower than average	**-0.001%**	**0.033%**	**0.077%**
	(-0.07)	(0.87)	(1.13)
slope 20% lower than average	**0.019%**	**0.058%**	**0.124%**
	(1.01)	(1.26)	(1.60)
slope 25% lower than average	**0.058%**	**0.091%**	**0.007%**
	(2.40)	(1.49)	(0.05)
slope 30% lower than average	**0.083%**	**0.101%**	**0.025%**
	(2.53)	(1.34)	(0.16)

Table 29
Profits from Trading Strategy Conditional on Lagged Trade Imbalance Based on the Method in Chordia and Subrahmanyam (2004)

This table reports the average returns over the period from June 1, 2005 to May 30, 2008 for the 2-year, 5-year, and 10-year notes. TIB is trade imbalance estimated by all trades, while TIB_FA1 is trade imbalance estimated by the aggressive (informed) trades. The returns are resulting from (i) the trading strategy that buys (sells) if the previous day's trade imbalance is positive (negative), or (ii) a trading strategy that buys (sells) if the trade imbalance is positive (negative) and large (more than one or two standard deviation from zero). If we buy (sell), we buy (sell) at the opening ask (bid) quote and sell (buy) at the closing bid (ask) quote. Return is the log changes of the first and last quotes of that day and it is in percentage points. t- Statistics are in parentheses.

	2-year	5-year	10-year
Panel A: TIB			
TIB positive or negative	**-0.0177%**	**-0.0149%**	**-0.0264%**
	(-4.06)	(-1.45)	(-1.71)
TIB one standard deviation above or below zero	**-0.0161%**	**-0.0132%**	**-0.0383%**
	(-1.98)	(-0.79)	(-1.6)
TIB two standard deviation above or below zero	**-0.012%**	**-0.0471%**	**-0.029%**
	(-0.44)	(-1.58)	(-0.44)
Panel B: TIBA1			
TIBA1 positive or negative	**-0.0135%**	**-0.0213%**	**-0.0198%**
	(-2.75)	(-2.04)	(-1.24)
TIBA1 one standard deviation above or below zero	**-0.0177%**	**-0.0272%**	**-0.0369%**
	(-1.95)	(-1.48)	(-1.37)
TIBA1 two standard deviation above or below zero	**-0.0267%**	**-0.00964%**	**-0.0849%**
	(-1.53)	(-0.22)	(-1.57)

Appendix 1
Macroeconomic Indicators

Construction Spending: It is defined as the dollar value of new construction activity on residential, non-residential, and public projects. Construction spending has a direct influence on stocks, bonds and commodities because it is a part of the economy that is affected by interest rates, business cash flow and even federal fiscal policy.

Factory Orders: Factory orders represent the dollar level of new orders for both durable and nondurable goods. The report can tell what to expect from the manufacturing sector, a major component of the economy and exert a tremendous impact on the financial market.

Employment Situation: The employment situation is a set of labour market indicators based on two separate surveys in this one report. The employment situation is the fundamental monthly indicator of aggregate economic activity because it contains all major sectors of the economy. A healthy labour market benefits the stock market because it supports economic growth and corporate profits, while bond traders are likely to concern about the potential for inflationary pressures.

International Trade: International trade is composed of merchandise (tangible goods) and services. It is available nationally by export, import and trade balance. Since trade balance is a valuable indicator of economic trends in the U.S. and abroad, trade figures can directly impact all financial markets, especially the foreign exchange market.

Treasury Budget: It represents the account of the surplus or deficit of the federal government. The budget data have several direct and indirect impacts on the financial markets. The most apparent relationship is between the size of the budget deficit and the supply of Treasury securities.

Retail Sales: Retail sales measure the total receipts at stores that sell durable and nondurable goods, in which consumer spending account for a large part. The situation in consumer spending usually the exert influence on stock and bond markets.

Producer Price Index: It is the measure of the average price level for a fixed basket of capital and consumer goods received by producers. By understanding price pressures in the pipeline, investors can expect inflationary outcomes in coming months.

Business Inventories: Business inventories are the dollar amount of inventories held by manufacturers, wholesalers, and retailers. The stock market prefers healthy economic growth because that leads to higher corporate profits. The bond market is more favourable for moderate growth that won't generate inflationary pressures.

Industrial Production: It is the index of industrial production available nationally by market and industry groupings. Industrial production is an important indicator of current output for the economy and helps to define turning points in the business cycle.

Consumer Price Index: The consumer price index is available nationally by expenditure category and by commodity and service group for all urban consumers (CPI-U) and wage earners (CPI-W), which has close relationship with inflation. Inflation basically tells how interest rates are set on everything from mortgage and auto loans to Treasury bills, notes and bonds.

Housing Starts: A housing start is registered at the start of construction of a new building intended primarily as a residential building. Changes in the rate of housing starts express the demand for homes and the outlook for the construction industry.

Leading Indicators: It is a composites index of ten economic indicators that should lead overall economic activity. By knowing leading indicators, investors will know what the economic background is for the various markets.

GDP: GDP represents the total value of the country's production during the period and consists of the purchases of domestically-produced goods and services by individuals, businesses, foreigners and government entities. GDP components such as consumer spending, business and residential investment, and inflation indexes reflect the economy's condition, which can translate to investment chance and understanding in managing a portfolio.

Personal Income and Outlays: It represents the income that households receive from all sources including wages and salaries, fringe benefits such as employer contributions of private pension plans, proprietors' income, income from rent, dividends and interest and transfer payments such as Social Security and unemployment compensation. To some extent, Personal Income and Outlays tells income and consumption situation. Increases in income and consumption will cause bond prices to fall.

New Home Sales: New home sales measure the number of newly constructed homes with a committed sale during the month. Specifically, trends in the new home sales convey important implications for the stocks of home builders, mortgage lenders and home furnishings companies.

Appendix 2

Macroeconomic Announcements

Announcement	Source	Frequenc	Units	Release
Construction Spending	Census	Monthly	%	10:00 am
Factory Orders	Census	Monthly	%	10:00 am
Employment Situation	BLS	Monthly	%	08:30 am
International Trade	BEA and Census	Monthly	$ billion	08:30 am
Treasury Budget	FMS	Monthly	$ billion	02:00 pm
Retail Sales	Census	Monthly	%	08:30 am
Producer Price Index	BLS	Monthly	%	08:30 am
Business Inventories	Census	Monthly	%	08:30 am
Industrial Production	FRD	Monthly	%	09:15 am
Consumer Price Index	BLS	Monthly	%	08:30 am
Housing Starts	Census and HUD	Monthly	Million	08:30 am
Leading Indicators	The Conference Board	Monthly	%	10:00 am
Durable Goods Orders	Census	Monthly	%	08:30 am
GDP	BEA	Quarterly	%	08:30 am
Personal Income and Outlays	BEA	Monthly	%	08:30 am
New Home Sales	Census and HUD	Monthly	Thousan d	10:00 am

Note: Census(U.S. Census Bureau), BLS(Bureau of Labor Statistics , U.S. Department of Labor), BEA(Bureau of Economic Analysis, U.S. Department of Commerce), FMS(Financial Management Service, U.S. Department of the Treasury, FRD(Federal Reserve of Board of Governors), HUD(U.S. Department of Housing &Urban Development)